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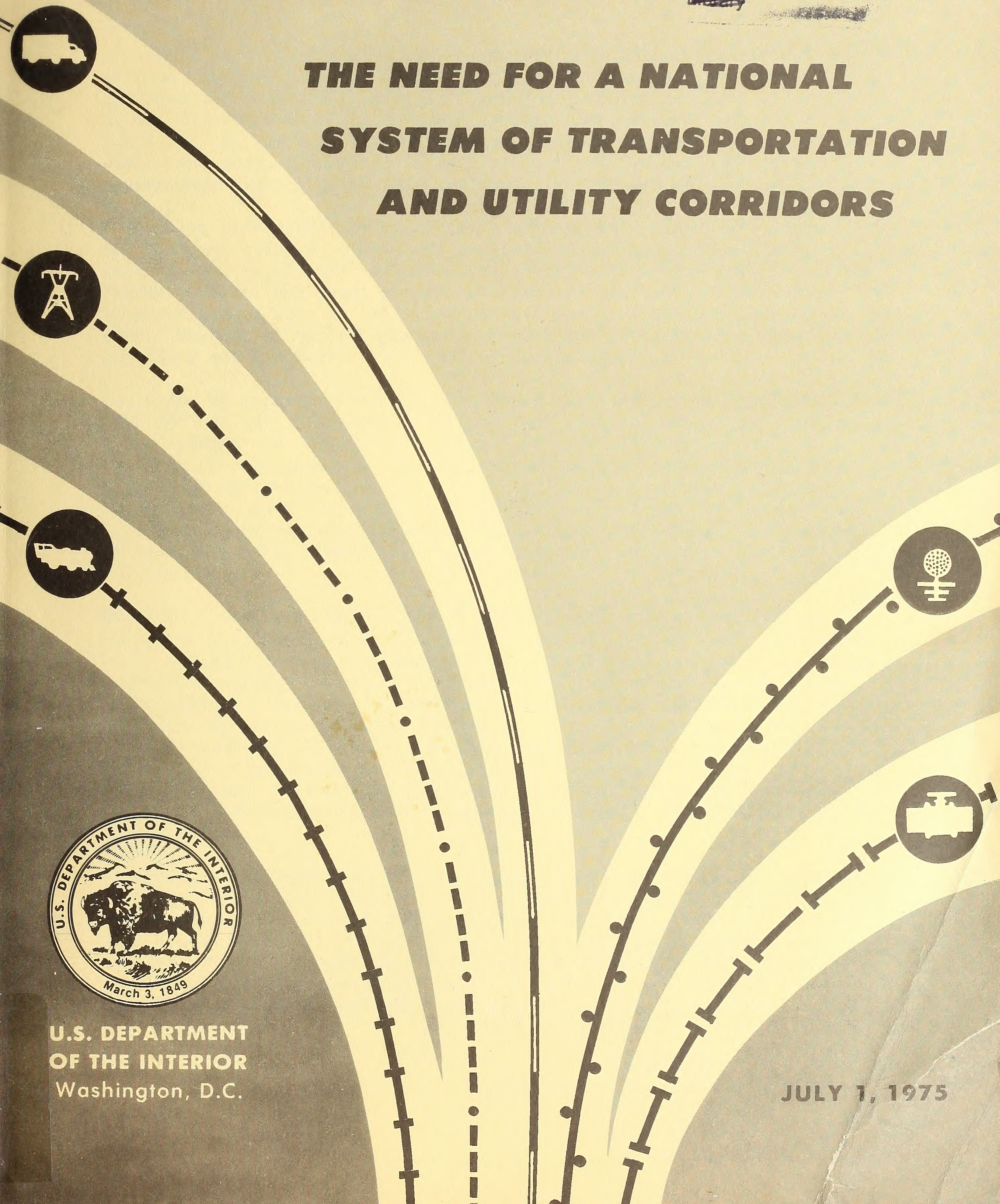
THE NEED FOR A NATIONAL SYSTEM OF TRANSPORTATION AND UTILITY CORRIDORS



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ABSTRACT

At the request of Congress, the Department of the Interior, Bureau of Land Management (BLM), studied the necessity and desirability of establishing a national system of transportation and utility corridors across Federal lands. Because of the high percentage of Federal lands and the concentration of indicated future right-of-way needs there, the study focused on lands west of the 100th Meridian (the approximate centerline of the continental United States).

Five major transportation and utility systems were examined: highway and railroad systems; electrical transmission systems; communication systems; and pipelines. Comments and contributions were solicited from Federal, State, and local government agencies, industry, and public-interest groups such as conservationists, preservationists, and the like. Without exception, their comments and criticisms were constructive and did much to add impetus to the study.

Two types of corridors were studied, each representing an extreme of corridor design: joint-use corridors, and planning corridors. Joint-use corridors are narrow, have fixed boundaries, and may contain more than one transportation or utility system, such as a gas pipeline and electrical transmission lines. Unlike joint-use corridors, planning corridors are more expansive, have flexible boundaries, and are a product of area or regional land-use plans, hence their name. Both types of corridors offer advantages and disadvantages which were weighed in the study.

What the study revealed is that in order to minimize ecological and environmental impacts and the proliferation of rights-of-way on Federal land, and at the same time develop and distribute much-needed new energy sources, a certain degree of flexibility will be needed when planning for corridors. Planning corridors, despite some obvious shortcomings, appear to be the most optimum action to take, In some instances, joint-use rights-of-way may also be appropriate, all factors considered, but depend upon the assessment of specific projects and individual siting circumstances. It was determined that the establishment of a national system of joint-use corridors in advance of specific project proposals is unfeasible.

In short, establishing a national system of transportation and utility planning corridors, as defined in this study, is feasible, desirable, and needed. Yet, as this study revealed, there is insufficient information from which to make an informed and intelligent decision as to how and where such a national system should be implemented. Until further statistical, technological, and environmental data are available from government, industry, and the public sector, corridor

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decisionmaking must continue on an ad hoc basis. Whenever an adequate baseline of information has been gathered and analyzed, a national policy can be articulated, and a national system of transportation and utility planning corridors can be established -- a system which will provide the optimum benefits to the public, to industry, and to the country.

ACKNOWLEDGMENT

Throughout this study, the corridor study staff received assistance from a variety of sources: the Bureau of Land Management field offices; other Federal, State, and local governmental agencies; the transportation and utility industries; and conservation and environmental interest groups. All were most helpful in providing the wide variety of information needed for this study.

For many, this assistance represented more than a single effort. Often it involved extensive time and considerable expense. To all the agencies, groups, and individuals who contributed to this report, the study staff extends its sincerest appreciation.

FOREWORD

The authority for this study was granted under Section 28 of the Mineral Leasing Act of 1920 (30 U.S.C. 185) as amended by the Act of November 16, 1973 (Public Law 93-153, 87 Stat. 576). Section 28(s) of the amended law relates to rights-of-way corridors and directs that: "In order to minimize adverse environmental impacts and to prevent the proliferation of separate rights-of-way across Federal lands, the Secretary [of the Interior] shall, in consultation with other Federal and State agencies, review the need for a national system of transportation and utility corridors across Federal lands and submit a report of his findings and recommendations to the Congress and the President by July 1, 1975."

Section 28(b)(1) of Title I, P.L. 93-153 further stipulates, ". . . For the purposes of this section, 'Federal lands' means all lands owned by the United States except lands in the National Park System, lands held in trust for an Indian or Indian tribe, and lands on the Outer Continental Shelf. . . ."

By Order No. 2960 of January 23, 1974, the Secretary of the Interior delegated to the Director, Bureau of Land Management (BLM), the responsibility and authority for compliance with the congressional mandate. A Utility Corridor Study Staff was established within BLM's Division of Lands and Realty. This staff was charged with conducting a study to determine the need for a national system of transportation and utility corridors across Federal lands, and with reporting its findings and recommendations.

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I. INTRODUCTION

A. Objective

The objective of this study was to determine if there is a need for a national system of transportation and utility corridors across Federal land and, if so, the feasibility of developing such a system and when.

B. Scope of the Study

Although the study team was charged with the responsibility for studying corridors across Federal lands only, it became evident that to assess the total impacts of such corridors, those non-Federal lands intermingled with and surrounded by Federal lands must also be addressed. Hence, this study has attempted to consider the corridor impacts on the whole, rather than fragmented geographic sections.

Major emphasis was concentrated on the United States west of the 100th Meridian (the approximate centerline of the continental U.S.) and Alaska. West of the 100th Meridian, the United States, exclusive of Alaska, consists of about 47 percent Federal lands. East of the 100th Meridian, less than 10 percent are Federal lands of which the majority are national forest lands. In addition, they are widely scattered and often intermingled with State, county, and privately owned land. Table I-1 lists the federally owned lands within each State; the general land status of the conterminous 48 States is portrayed on Map #1.

Approximately 97 percent of the land area in Alaska is currently federally owned. However, when the requirements of Public Law 92-203, the Alaska Native Claims Settlement Act (ANCSA), are satisfied and land selections due to the State under the terms of its Statehood Act are completed, Federal ownership will be significantly reduced. The approximately two percent of the acreage currently in Alaskan national parks and monuments is not considered by this study. This percentage will increase markedly if legislative proposals creating additional parks, submitted by the Secretary of the Interior to the Congress, are enacted.

The Secretary's current legislative proposals recommend an 83-million-acre expansion of the national park, forest, wildlife refuge, and wild and scenic rivers systems, under provisions of ANCSA. These proposals are portrayed on the general land status map of Alaska, Map #2.

TABLE I-1

FEDERALLY OWNED LAND – BY STATE
(AS OF JUNE 30, 1974)

STATE	ACREAGE OWNED BY THE FEDERAL GOVERNMENT	ACREAGE OF STATE	PERCENT OWNED BY THE FEDERAL GOVERNMENT
ALABAMA	1,109,368	32,678,400	3.4
* ALASKA	353,383,374	365,481,600	96.7
* ARIZONA	31,934,019	72,688,000	43.9
ARKANSAS	3,178,899	33,599,360	9.5
* CALIFORNIA	45,072,080	100,206,720	45.0
* COLORADO	23,939,395	66,485,760	36.0
CONNECTICUT	9,350	3,135,360	.3
DELAWARE	38,594	1,265,920	3.0
D.C.	10,210	39,040	26.2
FLORIDA	3,425,839	34,721,280	9.9
GEORGIA	2,205,542	37,295,360	5.9
HAWAII	417,015	4,105,600	10.2
* IDAHO	33,732,635	52,933,120	63.7
ILLINOIS	558,401	35,795,200	1.6
INDIANA	475,766	23,158,400	2.1
IOWA	224,150	35,860,480	.6
KANSAS	700,433	52,510,720	1.3
KENTUCKY	1,313,063	25,512,320	5.1
LOUISIANA	1,053,878	28,867,840	3.7
MAINE	130,642	19,847,680	.7
MARYLAND	198,736	6,319,360	3.1
MASSACHUSETTS	79,067	5,034,880	1.6
MICHIGAN	3,392,082	36,492,160	9.3
MINNESOTA	3,354,221	51,205,760	6.6
MISSISSIPPI	1,576,686	30,222,720	5.2
MISSOURI	2,058,902	44,248,320	4.7
*MONTANA	27,648,566	93,271,040	29.6
NEBRASKA	691,378	49,031,680	1.4
*NEVADA	60,832,171	70,264,320	86.6
NEW HAMPSHIRE	710,089	5,768,960	12.3
NEW JERSEY	130,204	4,813,440	2.7
*NEW MEXICO	25,867,262	77,766,400	33.3
NEW YORK	228,899	30,680,960	.7
NORTH CAROLINA	1,945,374	31,402,880	6.2
NORTH DAKOTA	2,295,131	44,452,480	5.2
OHIO	326,710	26,222,080	1.2
OKLAHOMA	1,513,371	44,087,680	3.4
*OREGON	32,223,014	61,598,720	52.3
PENNSYLVANIA	650,449	28,804,480	2.2
RHODE ISLAND	7,851	677,120	1.2
SOUTH CAROLINA	1,141,579	19,374,080	5.9
SOUTH DAKOTA	3,284,386	48,881,920	6.7
TENNESSEE	1,773,410	26,727,680	6.6
TEXAS	3,173,807	168,217,600	1.9
*UTAH	34,865,660	52,696,960	66.2
VERMONT	269,368	5,936,640	4.5
VIRGINIA	2,343,290	25,496,320	9.2
*WASHINGTON	12,575,626	42,693,760	29.4
WEST VIRGINIA	1,054,524	15,410,560	6.8
WISCONSIN	1,807,044	35,011,200	5.2
*WYOMING	30,067,664	62.343.040	48.2
SUB TOTAL * W. STATES	712,141,466	1,118,429,440	63.6
TOTAL U.S.	760,999,173	2,271,343,360	33.5

SOURCE: Public Land Statistics, 1974, Bureau of Land Management, Department of the Interior

Unless otherwise noted, the remainder of this report includes Alaska in any reference to lands within the Western United States.

It warrants noting that Alaska attained significance for this study because there, for the first time, Federal and State agencies have begun to formally coordinate efforts in land-use planning and development. Alaska's efforts are a prototype of the coordinated planning that should be conducted if many of our national goals are to be realized.

As a basis for conducting this study, the future right-of-way demands in the Western States and Alaska were projected through 1985. A 10-year planning horizon was considered the maximum for which future right-of-way demands could be projected with any reasonable degree of accuracy. This planning horizon was chosen based upon a consensus of other Federal Agency (regulatory and administrative) and industry representatives.

C. Contributors to the Study

Early in the study, a number of contacts were made to discuss the study requirements and objectives. Officials of other Federal Agencies (both regulatory and administrative) involved with Federal lands, the Governors of those States having significant acreages of Federal lands, and representatives of the highway, railroad, electric transmission, communication, and pipeline industries were consulted. In addition, the services of technical consultants were obtained. An organization chart for the study is given in Appendix B.

As a result of earlier meetings, an interagency coordination group was established to provide data sources and to review the study report draft. Also, a group of transportation and utility industry representatives was established to coordinate and provide data for consideration. They submitted technical data for incorporation into the study and provided assistance to the study team. These industry contacts were sources of expertise who provided pertinent and representative data relating to the respective right-of-way systems being analyzed.

Bureau of Land Management field office personnel provided data relative to the five major transportation and utility systems under consideration. Their inputs consisted of data and information held by BLM State and field offices. Other data furnished were based upon contacts with other Federal Agencies and with State and county governments.

An outline of the study was widely disseminated to other Federal Agencies, preservation and conservation groups, and other Interior Department Agencies. This was done to inform interested groups and to solicit input concerning the proposed study approach. Briefings were given to Washington area offices such as the Citizen's Advisory Council for Environmental Quality, and the Natural Resources Council of America. In this way, interested parties were apprised of the study, its purpose and tentative contents, and their contributions and concerns were solicited early enough to be considered by the study team.

D. Selection of Systems

A large number of transportation and utility rights-of-way exist across Federal lands within the Western United States. Many of these were not deemed relevant to this study because of their extremely short length and only local significance; they include such facilities as the gathering lines from wellheads to storage tanks in oil and gas fields and low-voltage (less than 115 kilovolt) power distribution and transmission lines. It would have been impossible to assess all such rights-of-way within the time allotted for this study.

Five right-of-way systems were identified as being the major transportation and utility systems within the United States and were selected for study. These five systems are:

- electric power transmission lines
- pipelines
- communication lines
- highways
- railroads

The minimum systems sizes considered to be pertinent for this study were:

1. Electric transmission lines of 115 kilovolts (KV) or higher for existing systems, and 230 KV or higher for projected future demands;

2. Natural gas transmission pipelines, coal slurry, and liquid petroleum trunk pipelines, usually 16 inches in diameter or larger for existing lines, and 24 inches or larger for projected future demands. Some smaller-size existing lines were included because of their interstate significance;

3. Non-microwave communication lines of 100 miles or longer;

4. Interstate and primary Federal highways; and

5. Railroads of 100 miles or longer for existing lines and 10 miles or longer for projected future lines.

E. Selection of Corridors

For the purpose of locating rights-of-way, this study examined two extremes of corridor concepts: the joint-use corridor and the planning corridor. A joint-use corridor is a narrow, restricted, heavily-utilized, linear area within which the rights-of-way of several transportation and/or utility systems may overlap or adjoin. Conversely, planning corridors are broad, linear land areas with fairly flexible boundaries. Such corridors are based upon coordinated land-use planning, hence their name. The actual locations of specific rights-of-way within a planning corridor would be determined during and following the planning corridor development based upon detailed analysis of proposed projects. Project sitings within planning corridors may or may not involve joint use of rights-of-way; project data assessment would determine when separate rights-of-way are more desirable. Relocating existing systems into future corridors was not envisioned as a viable action.

II. SUMMARY OF FINDINGS

A. General Findings

The study determined that a national system of planning corridors developed in accordance with area-wide or regional land-use plans that are coordinated among Federal, State, and local governmental agencies, private industry, and the public is both feasible and desirable. There is a need for such planning corridors on Federal lands to minimize the environmental impacts of transportation and utility systems and to avoid proliferation of separate rights-of-way -- proliferation meaning an excessive, rapid spread.

The study further determined that the establishment of a national system of joint-use corridors in advance of specific project proposals is infeasible. However, it may prove feasible to place portions of right-of-way systems in close proximity to each other once project design and site conditions are known.

And, of equal importance, the study revealed that the potential growth of electric transmission and pipeline systems in the Western States will dictate the greatest future demands for rights-of-way across Federal lands. Unless planned in a coordinated manner, these new pipelines and electric transmission lines have the potential for causing adverse environmental impacts and proliferation of rights-of-way.

B. Specific Findings

1. Uncoordinated locations of future rights-of-way across Federal lands could result in the loss of natural resources within or adjacent to the rights-of-way and excessive or unnecessary environmental degradation.

2. A significant increase is expected in the next ten years for electric transmission line and pipeline systems only. The greatest impacts of these systems on Federal lands will be with States west of the 100th Meridian.

3. If systematic and coordinated planning is not implemented, significant proliferation of pipeline and electric transmission line rights-of-way could result across Federal lands in the Western United States because of the development of energy resources.

4. Except for short connections between energy resource areas and existing systems, there is no substantial increase foreseen through 1985 for primary highway or railroad construction across Federal land in States other than Alaska. There is no significant increase foreseen through 1985 for construction of underground communication and electric transmission lines across Federal lands.

5. Each right-of-way system has specific minimum requirements for construction and operating space.

6. Joint use of rights-of-way is often both feasible and desirable. However, this determination depends on specific project evaluation -- each project and its requirements must be analyzed individually.

7. Electric transmission lines cause the greatest interference problems between systems in joint use of rights-of-way.

8. Joint use generally results in a compromise location for rights-of-way, particularly when there is variation in origin and destination of systems. In some instances joint use may not result in the environmentally optimum location.

9. Establishing specific joint-use right-of-way areas across Federal lands could determine the location of rights-of-way across non-Federal lands with a resulting influence on individual property values. Planning corridors would provide the flexibility of alternate routes, thereby minimizing such effects.

10. Planning corridors would not negate the need for case-by-case project analyses. Due to land management complexities and system interrelationships, land management agencies must retain the flexibility to assess all alternative locations, both within and outside of planning corridors.

11. Land-use planning in coordination with future transportation and utility planning is prerequisite to establishing planning corridors. Land-use planning at local, State, and regional levels lacks coordination and uniformity as related to right-of-way locations. Consistent land-use planning is necessary to provide uniform considerations for rights-of-way siting and management, especially in the preliminary and basic planning stages.

12. The amount of Federal land available for future right-of-way needs is diminishing with the continuing designation of special management areas. Future linear right-of-way needs must be fully considered before any Federal lands are designated as special management areas which would constrain right-of-way use.

13. Planning corridors can be established when an adequate information base (natural resources and their values) exists, future right-of-way needs are known, and both are coordinated among Federal, State and local governmental agencies plus industry.

III. RECOMMENDATIONS

The following recommendations are made based upon a determination of the need for a national system of transportation and utility corridors across Federal lands. These recommendations do not address specific corridor locations.

1. That Federal Agencies be directed to identify and reserve across Federal lands a national system of planning corridors, as defined in this study, which are suitable for and shall remain open to future routing of transportation and utility rights-of-way. Specific rights-of-way location (separate or joint-use) within these corridors must be determined on a project basis.

The establishment of such planning corridors must be predicated on the development of an adequate information base containing data on resources, resource values, and environmental values, along with future transportation and utility development needs within the States west of the 100th Meridian. Development of this information base will require the following actions:

a. Federal land managing agencies must be authorized and directed to mutually develop, consistent with their resource planning system programs, an areawide or regional resource and environmental information base in cooperation with State and local governmental agencies in the Western States.

b. Federal land managing agencies must be authorized and directed to mutually develop, consistent with their planning system programs, an areawide or regional evaluation of proposed or projected energy transmittal projects on and across Federal lands in the Western States in cooperation with State agencies, public utilities and private industry interests concerned with energy generation and transmittal.

(This recommendation based on findings 1, 2, 3, 4, 11, 12, and 13.)

2. That during the period in which the information base and evaluation of energy transmittal projects are being developed, for lands in the Western States, Federal land managing agencies be directed to grant individual rights-of-way, only after making a determination of the feasibility and practicality of combining individual rights-of-way into joint use on or across Federal lands. (Based on findings 5, 6, 7, and 8.)

3. That Federal land managing agencies retain flexibility to locate rights-of-way, consistent with Federal, State, and local land-use and land resource plans, which will result in the least total impacts, after full consideration of environmental, socio-economic and product delivery costs. (Based on findings 5, 9, 10, and 12.)

IV. THE NEED FOR CORRIDORS

A. Current Situation

1. Background and Definitions

The Congressional mandate was to determine the need for a national system of transportation and utility corridors across Federal lands. The legislation contains two criteria by which to determine the need: to prevent proliferation of separate rights-of-way, and to minimize adverse environmental impacts.

Because Federal lands are adjacent to and often intermingled with non-Federal lands, seldom would a corridor be located on Federal lands only. Consequently, in order to comply with the mandate and yet remain practical, the study team considered all lands, regardless of ownership, with special emphasis given to Federal lands.

For the purposes of this study, a corridor is defined as a linear strip of land forming a passageway between two points in which transportation or utility rights-of-way are now or may be located.

The study examined two opposite extremes of corridor concept. The first, planning corridors, involves broad linear areas with flexible boundaries. The second, joint-use corridors, involves a narrow linear area with restricted boundaries within which a part or all of any system could be located.

A planning corridor is a broad strip of land of variable width between two geographic points which has ecological, technical, or economic advantages over other adjacent areas for the location of rights-of-way anywhere within its boundaries. It assures opportunities for the location of future rights-of-way. Such corridors are a result of and dependent upon coordinated land-use planning founded upon a data base which includes identification of existing resources, resource values, environmental values, and future transportation and utility needs.

Such an information base must be developed through a cooperative planning effort by Federal Agencies involved with the public lands, State and local entities, private industry, and the general public.

In effect, the planning corridor process identifies the areas which will suffer the least environmental impact from and still be suitable for the location of future rights-of-way. Sufficient flexibility should be provided in any land-use plan so that, if it is later determined to be in the best public interest to locate a system in a route other than within the identified planning corridor, it is possible to do so.

Planning corridors must be of variable widths, two miles generally considered the minimum, depending on the land-use data base.

A joint-use corridor is a narrow strip of land with restricted boundaries in which facilities of the same or different systems are placed adjacent to each other in as close proximity as practical and feasible. Joint-use corridors are considered to be in the general range of 500-feet to 1 mile wide depending on the number and kinds of systems involved. The maximum width would be no more than that necessary for all systems to function with almost no interference between them. However, this width may not necessarily be the most desirable. The study found that optimum spacing between systems is determined by a complex set of interacting variables that must be quantified and analyzed, and trade-offs made before a specific joint-use decision can be reached.

Each specific joint-use situation must be analyzed in relation to the following technical and physical variables.

1. The systems involved, their size, design, and potential for expansion;
2. The physical characteristics of the site, particularly terrain, soil, bodies of water, and land use;
3. The length that the systems parallel;
4. The potential interference between systems;
5. The mitigation practices and their costs to reduce interference problems;
6. System reliability, safe operation, and maintenance; and
7. The resource and environmental values to be affected by the uses within the corridor.

2. Proliferation

Although 70,000 separate grants for rights-of-way were awarded over the years there is no data identifying the kinds and sizes of these rights-of-way (Senate Report 93-207 and Federal Agencies records). Since only summary data were available to the study team, there was no way to relate this data to the five systems under consideration, nor were there any statistical data pertinent to the acreages involved and the rate of spread. Consequently, since it was impossible from the available data to determine any past proliferation trends, the study team felt it would be more fruitful to assess future right-of-way developments and the potential proliferation therefrom.

Published data and projections from industry sources and Federal and State agencies were consulted, resulting in the following observations of each system's potential for expansion on Federal lands (Data sources are listed in Appendix A). These projected developments will not be located totally on Federal lands but will nonetheless have significant impacts on them.

Electric Transmission (See Map #5 for the existing and projected system.)

- Western Systems Coordinating Council projects that 20,500 circuit miles of new electric transmission lines will be needed by 1984 in the Western States. (Total electric demand growth rate just under 7 percent per year.)
- Even with full conservation measures, Federal Energy Administration's projections indicate significant growth in electric transmission. (Total demand growth rate 4 percent per year.)
- Federal lands will be involved, especially for right-of-way needs associated with new coal-fired generating plants.

Pipelines (See Map #6 for the existing and projected system.)

- Some 11,400 miles of pipelines involving Federal lands are under study, proposed, or have right-of-way applications on file with agencies.
- Development of Rocky Mountain oil, natural gas, and coal resources will require pipelines for all products to link resource areas with existing pipeline systems.

Communications (See Map #7 for the existing and projected system.)

- Two new coaxial cables - St. Louis to Los Angeles and Los Angeles to San Francisco - will essentially complete existing buried facilities affecting Federal lands.
- Future needs will be met by expanding the capacity of existing systems including coaxial cable, microwave, and satellite technologies. The buried waveguide system being tested is not expected to affect Federal lands. (Communications industry sources.)

Highways (See Map #8 for the existing system.)

- The Interstate Highway System in the conterminous 48 States is 84 percent complete with an additional 15 percent under construction or in the planning stages. Significant expansion is not expected.
- Primary highways will be improved by widening and minor relocations.
- New highways will be needed to link resource development areas with existing network.

Railroads (See Map #9 for the existing system.)

- Total miles of mainline track is declining.
- No significant demands for new rights-of-way are seen in the conterminous 48 States except for linking resource areas with existing systems where railroads will be the selected mode for transportation.

Electric transmission and pipeline systems are the only ones with appreciable right-of-way growth anticipated through 1985. It is expected that there will be an increased need in the near future for rights-of-way across Federal lands for these two systems because of increasing per capita consumption of energy and the President's Project Independence Program to make the United States energy self-sufficient within the 1980's. This will require linking of developing coal, oil, and gas fields (and possibly oil shale) with the market areas. Such linkage will be either through physical movement of energy resources for power generation and petroleum refining, or from on-site energy development followed by transportation to markets. The extent and timing of such development cannot be accurately predicted at this time.

Such energy resource development is further emphasized by President Ford's January 17, 1975, energy program statement that ". . . within the next 10 years, my program envisions:

> 200 major nuclear power plants;
> 250 major new coal mines;
> 150 major coal-fired power plants;
> 30 major new oil refineries;
> 20 major new synthetic fuel plants; and
> the drilling of many thousands of new oil wells."

Most assuredly, such future developments are expected to impact Federal lands by requiring plant sites and related rights-of-way for electric transmission lines and pipelines. Known fossil fuel and geothermal resource area locations where this development may occur are shown on the organic fuel deposit Maps, #3 and #4.

Energy conversion facilities such as coal gasification plants; nuclear, geothermal, and fossil fuel power generating plants; and oil shale plants will require rights-of-way to transport the primary commodity. Remote sites will also require service rights-of-way to bring in water, build access roads, and provide electricity and communications. Although most site locations for rights-of-way cannot be precisely identified at this time, significant rights-of-way associated with energy conversion plants can be anticipated.

Current energy resource development proposals stop short of specifically selecting or recommending transportation modes and market or end-use locations. Consequently, future needs for rights-of-way must be expressed in general terms, without advocating any particular developmental thrust.

The individual system maps for electric transmission lines and pipelines indicate the general location of proposed lines. The importance of Alaskan oil and gas discoveries is indicated by a trans-Canada natural gas pipeline project proposal. Several of the pipelines involved are shown on Map #6. For Federal lands, crude oil pipelines being discussed at this time are from the West Coast to Midland, Texas, and Midwest refineries, once Alaskan crude is delivered to the West Coast by tanker.

Reports such as the Northern Great Plains Study, 1974, by the Department of Interior and the Project Independence Report, 1974, by the Federal Energy Administration, estimate quantities of energy resource to be transported from organic fuel deposit areas in the next 10 years. However, these estimates have been based on a multitude of variable factors which depend on priorities or emphases of Federal policies. For example, the FEA's Project Independence Report indicates that about 17 percent of America's coal flows out of Western coal fields in the Northern Great Plains, Rocky Mountains, and the Pacific Coast, where the majority of the Federal lands are located. The report states that demand levels for the next 10 years are not projected to bring about massive development of the Western coal fields. However, if the demand for low-sulphur-content coal is increased significantly, the flow of coal from Western coal fields could increase accordingly. Again, this increase would depend on Federal and State policies and priorities. This report does not attempt to analyze the quantities estimated in such energy reports, but it does recognize the potential for such energy resource development and attendant impact upon Federal lands without attempting to predict when, where, and to what extent such development may occur.

Although data reviewed in this study have not indicated a general tendency toward right-of-way proliferation, in the sense of "excessive, rapid growth" across Federal lands it can be anticipated that extensive development of the natural resources in the Western States could result in a proliferation of rights-of-way if land-use is not properly planned.

3. Environmental Impacts

The second criterion specified by Congress in reviewing the "need" for a national system of transportation and utility corridors across Federal lands involved minimizing adverse environmental impacts resulting from right-of-way development. The National Environmental Policy Act of 1969 (NEPA) requires an assessment of environmental, social, and economic impacts resulting from any major Federal actions having a significant environmental impact. The NEPA requirements open the decisionmaking process to public scrutiny and provide opportunities for judicial determination of compliance with the law. Environmental impact statements are drafted by Federal Agencies to assess the impacts of projects and the alternatives for consideration in the decisionmaking process. A draft is circulated to other agencies and the public for comment. The comments received and those adopted appear in the final environmental impact statement, which accompanies the proposed action through the decisionmaking process.

The NEPA process requires environmental inventories or baseline studies including detailed information regarding the proposed action. For rights-of-way, this involves a detailed description of the project including size, design, construction techniques and timing, and mitigation and safety practices. Viable alternatives to the project and alternative locations must also be identified and their impacts described. Under current practices, opportunities for paralleling other systems may be explored but such explorations are not mandatory.

It is questionable whether sufficient detailed information would be available to draft a single, adequate environmental impact statement for all future systems that may be located in a planning corridor or joint-use right-of-way. A decision would have to be reached on each proposed project to determine if joint use or a separate route would minimize impacts after sufficient information on the project is available. However, the resource data base used in identifying a planning corridor could be used in preparing environmental impact statements for specific project proposals, resulting in savings of time and money and less duplication of effort.

Individual rights-of-way have varying impacts upon the land they cross. For example, rights-of-way for buried systems such as pipelines, communication lines, and electric transmission lines, temporarily disturb the land and disrupt its use. But, after a period of time, depending upon soil and climate, the land may return almost to its original condition or usage.

Conversely, highway and railway system rights-of-way permanently disrupt land use, for they must command complete land control throughout the life of their service, negating any possible return to prior usage.

The major impacts of linear rights-of-way, either separate or joint-use can best be discussed in terms of surface disturbance, air and water quality, visual and audible effects, and social and cultural impacts, and it is in these terms that they are discussed in this study.

The following discussion is not intended to be a complete analysis of adverse impacts. It does recognize, however, that there can be a direct conflict between the development of rights-of-way and the management of wildlands and open spaces. And, from that context, its purpose is to illustrate the major environmental concerns and values associated with the development of rights-of-way.

a. Surface Disturbance

Construction activity for all systems involves various degrees of right-of-way clearing, soil disturbance, and displacement. Pipelines and buried communication cables require a cleared and rough-leveled construction area wide enough for equipment and vehicles to operate. They do not require large cut-and-fill sections except in side hill situations. Highways and railroads may clear and disturb the entire right-of-way and in addition have wider areas for cut-and-fill sections. Electric transmission lines necessitate clearing trees that will interfere from the right-of-way. but low-growing vegetation remains. Tower sites and access roads are cleared of vegetation and a working area is leveled. The degree of erosion, nutrient loss, and downstream siltation experienced depends on the amount of area cleared, soil type, terrain, rainfall characteristics, and the erosion control measures practiced. Many times these disturbances can be temporary if the sites have good soil and climatic conditions, and the disturbed areas are reseeded.

In addition to altering the land, right-of-way construction also may affect the wildlife, aquatic life, and marine biota in the area of the construction site. For example, right-of-way fencing, common to railroads and highways, can interrupt migration and drift patterns of some wildlife species and domestic animals. And, conversely, the access and service roads associated with rights-of-way provide access to wildlife areas heretofore unavailable to vehicles, disturbing habits and breeding patterns of some species of game. In addition, construction may alter the native vegetation, perhaps to the benefit of some species, but to the detriment of others.

These factors must all be considered when planning the kinds of rights-of-way to be developed and where they are to be placed.

b. Air and Water Quality

Lakes, rivers, and streams, too, are affected by construction. Some sedimentation and erosion is unavoidable when large amounts of earth are being moved, which can be critical if spawning beds are being fouled; aquatic life may be affected, as well as potable water supplies.

Dust from construction equipment and emissions from construction vehicles temporarily degrade air quality adjacent to construction sites. The air is fouled and the dust coats anything in the near vicinity. In addition, the dust pall raised is physically and aesthetically unpleasant.

c. Visual and Audible Impacts

Due to their linear nature, right-of-way construction activities and the unavoidable scars left on the land are highly visible. Swaths cut through timber and the abrupt conversion of heavy shrub cover to grass and forbs can be visible for miles. When this change occurs in an area where examples of man's activity have not been evident, it often adds a discordant line that attracts attention. The impact of such lines on the landscape varies with the terrain, vegetative cover, and the presence or absence of linear patterns such as roads, fences, farm fields, and other rights-of-way.

Aboveground structures also increase visual impact. Transmission line towers can be aesthetically designed, but remain highly visible and obtrusive when placed in otherwise unspoiled settings.

Construction equipment noise and blasting noise can have a severe but short-lived impact on wildlife and the human values associated with solitude. Traffic and pumping station noises are less severe following construction but will continue for the life of the project.

d. Cultural Considerations

Without some sort of protection, archaeological, historical, or religious sites may be altered and destroyed by right-of-way and related construction activity. If vehicle access was not available before construction of the right-of-way, this access may lead to vandalism of such sites.

Impacts in the major categories of environmental concerns -- surface disturbance, air and water quality, visual and audible impacts, and cultural considerations -- can and are being reduced through legal and regulatory requirements and voluntary measures. For example, controls on construction practices and timing, plus revegetation efforts reduce erosion and wildlife disturbance; stipulations are used in right-of-way grants to require compliance with air and water quality standards and laws protecting historic and archaeological sites; and frequently, right-of-way applicants fund research and other special studies to determine the extent of adverse impacts on certain species and what mitigating measures can be devised. These measures are important, but they would be applied equally in a corridor or in separate right-of-way situations. Even with existing regulatory and voluntary controls, problems remain concerning both the number of and locations for rights-of-way.

e. Environmental Impact Comparison-- Joint-Use vs. Separate Rights-of-Way

To accurately compare the environmental impacts of joint-use vs. separate rights-of-way, one would have to have an extensive information base, including total resource identification and its value, environmental values, and social values. The data reviewed for this study indicated that such a data base presently does not exist for all lands within the study scope. Therefore, the following comparison examples will only indicate the possible savings in surface disturbance and land area commitment which may be anticipated from joint use. (Technical problems of joint use are discussed in the feasibility section.) In these examples, pipelines and electric transmission lines are anticipated to be the only systems having a significant need for future rights-of-way across Federal lands.

- Pipeline Parallel to Existing Pipeline

  The spacing shown in Figure IV-1 indicates a 57 percent savings in new surface disturbance for a 48-inch pipeline if it is built adjacent to another pipeline in normal soil. This represents 10.4 fewer acres per mile for the situation shown compared to a separate pipeline route. Additional reduction in surface disturbance may result by the second pipeline sharing the access road, electrical power, and communication facilities of the original pipeline.

- Pipeline - Railroad Parallel

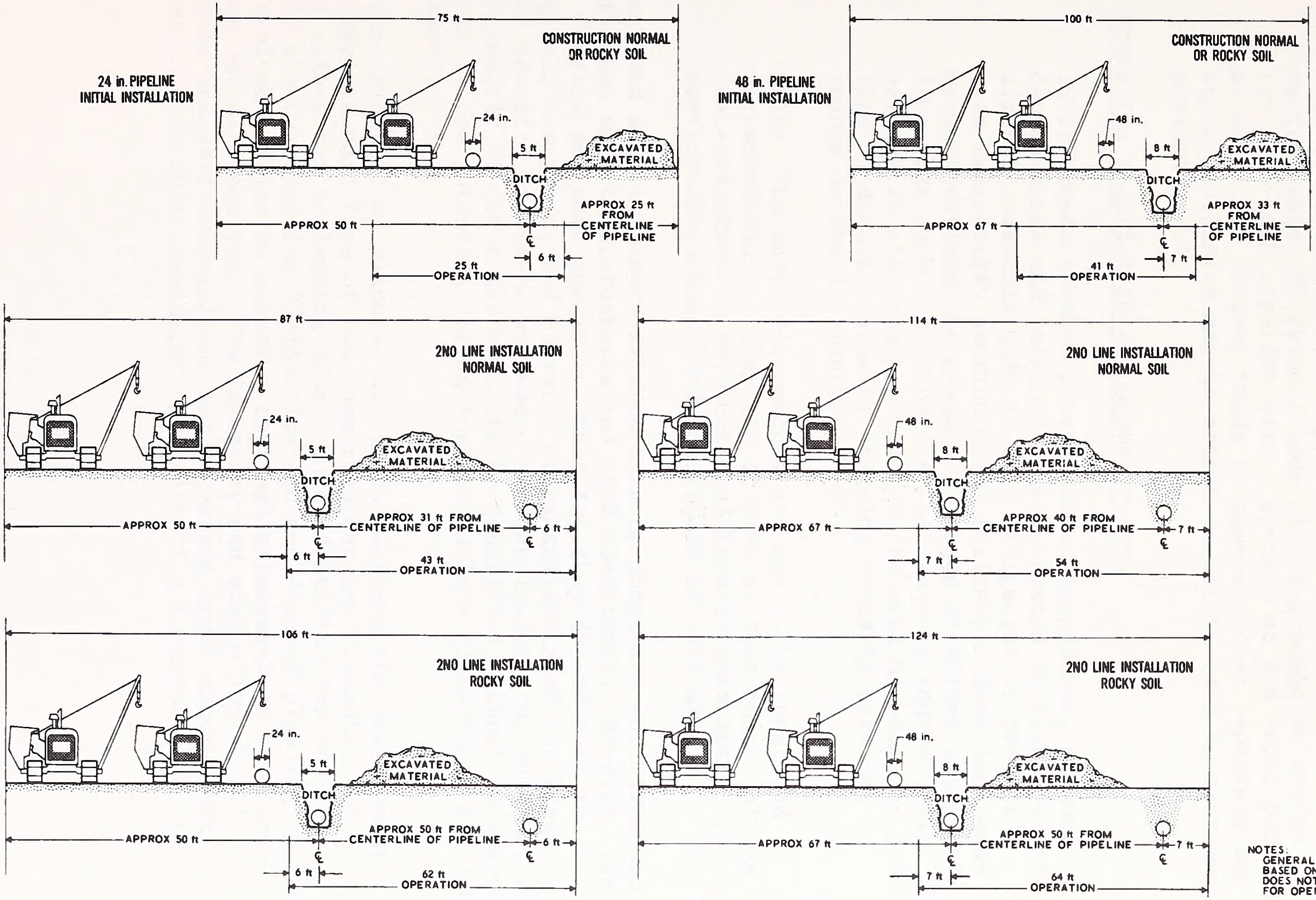
  A 50-foot overlap into an area cleared for a 200-foot railroad right-of-way (leaving a 50-foot buffer area to the edge of the track for safety) results in 50 percent less clearing for a 48-inch pipeline and a savings of 6 acres per mile of parallel use. Savings may also result by sharing the railroad access roads and the communication facilities.

- Pipeline - Highway Parallel

  With a 30-foot overlap into the area cleared for a highway right-of-way (leaving a 50-foot buffer area between the pipeline and the edge of the shoulder of the highway for safety), 30 percent less clearing is needed for a 48-inch pipeline and there is a 3.6-acre saving per mile of parallel. Separate access would be needed along the pipeline between interchanges on controlled-access highways, thus no access savings.

FIGURE IV-1

PIPELINES - SINGLE-USE RIGHTS-OF-WAY
(Typical Installations)



NOTES:
GENERALLY, ROW WIDTH ACQUIRED IS BASED ON CONSTRUCTION NEEDS - DOES NOT REVERT TO WIDTH NEEDED FOR OPERATION

SOURCE: The Aerospace Corporation, 1975

- Pipeline - Buried Communication Cable Parallel

  With a 40-foot cleared right-of-way on one side of a communication cable, 40 percent less clearing would be needed for a 48-inch pipeline with a savings of 4.8 acres per mile of parallel. Access roads to communication repeaters and other facilities may be shared resulting in a further land savings.

- Powerline Parallel to All Other Systems

  Interference between powerlines and pipelines, communication lines and railroads makes savings in right-of-way clearing possible only if full mitigation is provided (see feasibility section which follows). Some land commitment savings are possible between pipelines and powerlines but each situation must be assessed individually. No savings in clearing are realized between highway and powerline if a buffer area of standing trees is retained to reduce aesthetic impacts.

  NOTE: The above discussions are not to be construed as recommendations. They are offered at this point only as quantification of environmental impacts associated with surface disturbance and commitment of land area.

As mentioned earlier, there is much more to comparing environmental impacts than surface disturbance and land commitment. However, the other factors are site specific. That is, they depend upon the ecological, aesthetic, and cultural characteristics of the area and the specific rights-of-way uses. In conclusion, the only environmental benefit of joint use that can be quantified without site-specific data is the potential for savings in surface disturbance and land commitment.

The identification of planning corridors requires the development of a complete data base of the resources and environmental and social values for a planning area. Such identification would provide the baseline for flexibility and coordinated planning by all involved parties to assure a thorough assessment of the interactions and alternatives. The inventory and evaluation of all resources and environmental and social values would assure that they were given full consideration in locating future routes.

4. Findings:

- Future development of energy resources could result in proliferation unless coordinated planning for rights-of-way is implemented.

- A significant number of rights-of-way across Federal lands will be needed in the next 10 years for electric transmission lines and pipelines.

- No substantial increase in primary highway, railroad, or communication line rights-of-way is anticipated through 1985 across Federal lands except in Alaska.

- A comparison of individual rights-of-way vs. joint use requires a case-by-case analysis to quantify all of the environmental impacts of each.

- In general, pipelines being located in parallel with existing systems, except electric transmission lines, could result in about 30 to 60 percent savings in vegetative clearing requirements, when all routes coincide.

- Since rights-of-way involve both Federal and non-Federal lands, impacts on intermingled and adjacent non-Federal lands must be considered.

B. Feasibility of Corridors

1. Planning Corridors

A planning corridor by definition is wide enough to permit alternate routing of rights-of-way, including separate rights-of-way, within its boundaries. Therefore, the feasibility of establishing planning corridors does not depend on compatibility between right-of-way systems or similar physical and technical factors generally associated with joint use of rights-of-way. Important, however, are the engineering and cost factors relevant to the establishment of planning corridors. The area within a planning corridor should, to the extent possible, satisfy the requirements of: (1) minimizing environmental impacts; and (2) being suitable for location of linear rights-of-way. These two objectives are not always harmonious. Therefore, engineering and cost considerations can suffer in the compromise between the two, especially when the project termini lie outside the planning corridor and additional mileage is required.

As mentioned previously, the key to insuring the engineering and economic feasibility of planning corridors is maintaining the flexibility to adjust the corridor boundaries to accommodate new project proposals and even to allow routing outside the corridor when warranted. If the planning corridor is identified, established, and managed as suggested by this study, it will be feasible from an engineering and economic efficiency standpoint.

The main questions concerning the feasibility of establishing planning corridors are: (1) Do the Federal land managing Agencies have the authority to establish and reserve planning corridors? (2) Are adequate planning data available? (3) Who should be involved in the establishment of such corridors?

a. Authority

The basic power and authority over the public domain lands of the United States are derived from Article IV, Section 3, Clause 2 of the United States Constitution. The Congress granted this authority to the Secretary of the Interior by the Act of April 25, 1812, 2 Stat. 716 (R.S. 453, 43 U.S.C. 2), and Reorganization Plan No. 3 of 1946 (60 Stat. 1100). The Picket Act of June 25, 1910, as amended (43 U.S.C. 141, 142), and Executive Order 10355 of May 26, 1952 (17 F.R. 4831) delegated to the Secretary of the Interior full authority to withdraw or reserve ". . . lands of the public domain and other lands owned or controlled by the United States in the continental United States or Alaska . . . ." Section 2 of this Executive Order authorized the Secretary to ". . . issue such rules and regulations and to prescribe such procedures. . ." as are necessary for the exercise of this withdrawal and reservation authority. Pursuant to this authority, the Secretary may withdraw or reserve lands for any public purpose, including utility or other right-of-way corridors.

On acquired Forest Service lands, no specific withdrawal authority is required. However, the Forest Service cannot authorize uses which interfere with any valid existing rights, such as easements and mineral rights. These existing rights could be a factor to be reckoned with when establishing specific planning corridors. However, the constitutional authority, as cited above, does exist by which planning corridors can be implemented.

b. Availability of Data Base

Total resource, environmental, and land use data -- the data needed for planning corridors -- are unavailable at this time for the Western States. Such a data base has been established in a prototype for Alaska by a Joint Federal-State Land Use Planning Commission. It is used for delineating tentative corridors relative to the requirements of the Alaska Native Claims Settlement Act for reservation of public easements and requirements of Public Law 93-153 which amended the Mineral Leasing Act of 1920. A data base for the Western States should include all land -- Federal, State, and private -- if planning corridors are to be delineated successfully. In addition to projected transportation and utility system needs, it should contain at least the following basic information categories:

- Climate
- Topography
- Geology and Minerals
- Water
- Soils
- Scenic and Recreational Resources
- Biotic Communities
- Human Population
- Economics
- Land Status
- Existing Land Use
- Historic and Cultural Resources
- Resource Development

Much of the resource and land-use data exist in various forms and depth, but they must be reviewed, supplemented, updated, and compiled. But, even with proper coordination and adequate funding, it will take time to acquire and develop the information base. How much time is indicated by legislative proposals and Federal Agency estimates. For example, recent legislative proposals indicate a range of 5 to 8 years will be required for grant programs to the States for land-use planning. According to Bureau of Land Management estimates, it would take at least 5 years to complete effectively an existing natural resource planning base on the 474 million acres under its administration.

c. Coordination

As has been emphasized, the successful establishment of planning corridors would require a coordinated effort involving Federal, State, and local governments; public and private utilities; and the public. Unfortunately, there is no existing mechanism, such as a national land resource management act, to initiate this coordination. As of March 1975, four of the Western States had enacted land-use legislation and seven had enacted utility-siting acts (Source: State Government Offices). But, for the most part, these are recent laws, and the coordination necessary remains to be fully realized. Some counties, too, have developed land-use plans, but according to Bureau of Land Management field office personnel, none have addressed right-of-way needs directly.

Moreover, it is impossible to establish a feasible system of planning corridors without a deep involvement by the industries concerned, particularly the electric and pipeline companies with their predicted heavy demands in the future. Their professional assistance must be utilized simultaneously with the data base in evaluating suitable areas for the location of rights-of-way.

And, because planning corridors would encompass lands of non-Federal ownership, and nearly all would abut non-Federal land, public input would also be needed to effectively establish acceptable planning corridors.

2. Joint Use of Rights-of-Way

During this study, many cases of joint use of rights-of-way were examined. Although some problems have occurred, most systems in joint use are operating satisfactorily. The important point, however, is that the systems were placed in joint use only after: (1) an individual determination of need for joint use, and (2) an evaluation of systems compatibility based on specific project data. These two considerations - need and compatibility - will remain primary factors in future joint-use decisions.

This study cannot report categorically on the feasibility of joint use of rights-of-way. Research revealed that the question of feasibility must be addressed on an individual case-by-case basis and depends on engineering factors influencing the location of each system, the technical compatibility of the systems in parallel, the cost considerations relating to joint use, and the effect of joint use on systems reliability. These factors are discussed in the paragraphs which follow.

a. Engineering Considerations

A major consideration in evaluating the feasibility of joint use is a comparison of the engineering criteria controlling the location of the various systems. It was found that joint use of rights-of-way is usually a compromise not representing the optimum location for all joint users. This does not in itself make joint use infeasible. However, conflicts among engineering criteria can increase to a level where parallel locations become no longer feasible or practical from an engineering standpoint.

The basic engineering requirements for the location of each system are:

(1) Electric Transmission Lines

The ideal route for electric transmission lines is a straight line: it saves materials, reduces construction costs, and minimizes electrical power losses. However, since the ideal is rarely encountered, transmission lines are often built through mountainous terrain, across gorges and rivers, and other less-than-ideal conditions. To do this, towers must be located on stable ground and designed to withstand weather extremes which require special and costly design and construction.

(2) Pipelines

Economics dictate using the shortest route practical. Horizontal and vertical alignments are not critical but bends and slope increase pumping costs. The right-of-way must be cleared, with a construction area graded for the entire length. For obvious reasons, rocky soils are avoided where possible, as are steep canyons and rivers, fault zones, and landslide areas.

(3) Communication Lines

The most desirable route is the shortest path. Soils which can be easily trenched are best for underground cable locations. Steep canyons, rivers, fault zones, and landslide areas are avoided where possible.

(4) Highways

Routes for highways are primarily influenced by the location of population centers and the physical features of the terrain and drainage patterns. Highways are restricted by grades and must meet certain vertical and horizontal curvature criteria. Easily excavated high-strength permeable soils are preferred for highway construction.

(5) Railroads

Railroads are extremely grade-sensitive, and their routing is strongly dependent on terrain and associated drainage. Stable soils are preferred to reduce railroad costs. Like highways, railroads require considerable excavation and follow winding paths through rolling or mountainous terrain.

Table IV-1 lists typical right-of-way requirements.

Table IV-2 illustrates the physical incompatibility among some systems due to grade constraints.

TABLE IV-1

RIGHT-OF-WAY WIDTH REQUIREMENTS - BY SYSTEM

System	WIDTH REQUIRED DURING Construction and Major Repairs	Operation
Electric 1/		
230 KV	100-150	100-150
345 KV	150-170	150-170
500 KV	135-200	135-200
765 KV	200-225	200-225
400 KV (direct current)	140-150	140-150
Pipeline 2/		
1-24" (loamy or rocky soil)	75	25
1-48" (loamy or rocky soil)	100	41
2-24" (loamy soil)	87	43
2-48" (loamy soil)	114	54
2-24" (rocky soil)	106	62
Railroad 3/		
2 tracks	100-200	100-200
Highway (4 Lanes)		
Restricted (no expansion of frontage road)	90-110	90-110
Intermediate (no frontage road)	140-180	140-180
Desirable	210-310	210-310
Communication 2/		
Overhead open wire	50	16
Buried shielded pair	25-30	16-30
Buried coaxial cable	100	50
Buried wave guide	100	50

1/ The ranges shown are for single-circuit lines, but will generally accommodate most double-circuit line designs.

2/ Industry practice is normally to retain entire construction right-of-way width on non-Federal lands.

3/ Federal Railroad Right-of-Way Act of 1875 set right-of-way width at 200 feet.

SOURCES: The Aerospace Corporation, 1975 and the Electric Industry

TABLE IV-2

MAXIMUM ALLOWABLE GRADE - BY SYSTEM

System	Maximum Allowable Grade
Electric Transmission Line 1/	100%
Communication Line	100%
Pipeline -oil and gas 2/	---
-coal slurry	13-16%
Highways -design speed, 70 m.p.h.	3%
-design speed, 60 m.p.h.	4%
-design speed, 50 m.p.h.	5-7%
Railroads	1% (desired) 2.2% (rare)

1/ It is seldom that a tower is located on a 100 percent (45°) slope. Conductors have no grade restrictions.

2/ There are no standard maximum grades for oil or gas pipelines. Technically, it is possible to pump vertically.

SOURCES: The Aerospace Corporation, 1975 and Energy Transportation Systems Incorporated, 1974.

As an example of conflicting location criteria, consider a proposal to parallel an existing electric transmission line with a new pipeline. Assume the powerline traverses a mountainside with the towers located on rocky ridges and the conductor spanning draws. This is a reasonable transmission line location, but such a location could cause problems in pipeline construction, such as difficult access, solid rock excavation, drainage interference, and potential landslides. If these problems are severe enough, a parallel location for the pipeline would be ruled infeasible for strictly engineering reasons.

But, the study found that physical conditions are often such that at least some of the systems can sometimes be located parallel and adjacent. In addition to physical constraints joint use entails certain technical compatibility problems, as discussed in the following section.

b. Technical Compatibility

Figure IV-2 shows the interaction between the five systems in joint use of rights-of-way. Although the systems affect each other in varying degrees, high voltage electric transmission lines present the greatest problems for joint right-of-way usage. This is due to electrical phenomena associated with powerlines which, if not mitigated, can adversely affect nearby facilities. Radiation from powerlines can interfere with AM radio and television reception and can produce an audible crackling noise. These effects would be of interest when considering a joint use between a transmission line and a highway where commercial and residential developments or highway rest areas may be involved.

Of more serious consequences are voltages and currents which can be induced into metallic objects close to a transmission line, particularly where long parallels are present. In addition to interference with wire communication and railroad signaling systems, these induced voltages and currents present shock hazards. They can also, in certain conditions, contribute to corrosion of buried pipelines and cable sheaths.

Another problem involves what are called "fault currents." If a transmission line current reaches the ground (for example from a lightning strike), it can flow through the earth and enter a pipeline or buried cable resulting in damage to terminal equipment, ruptured pipelines and shock hazards.

The type and degree of incompatibility depends on such variables as the design characteristics of each system, the separation between systems, the length of parallel, the resistance of the soil to the flow of electricity, and climatic conditions.

The usual means of avoiding potential incompatibilities is to provide adequate separation between the systems. Minimal spacings for acceptable performance would result in a corridor configuration similar to that shown in Figure IV-3. This configuration assumes flat, rural land with suitable soil conditions for all systems.

Figure IV-4 assumes the same systems and conditions, but the systems were rearranged and the corridor width compressed, locating all other systems within the influence of the electric transmission line. Mitigation measures can be employed to reduce the electrical effects to an acceptable level, but the type and amount of mitigation can only be determined through close coordination among technical experts on a specific project basis. In this example, mitigative measures may be required on all systems except the highway, in order for this joint use to be feasible.

FIGURE IV-2

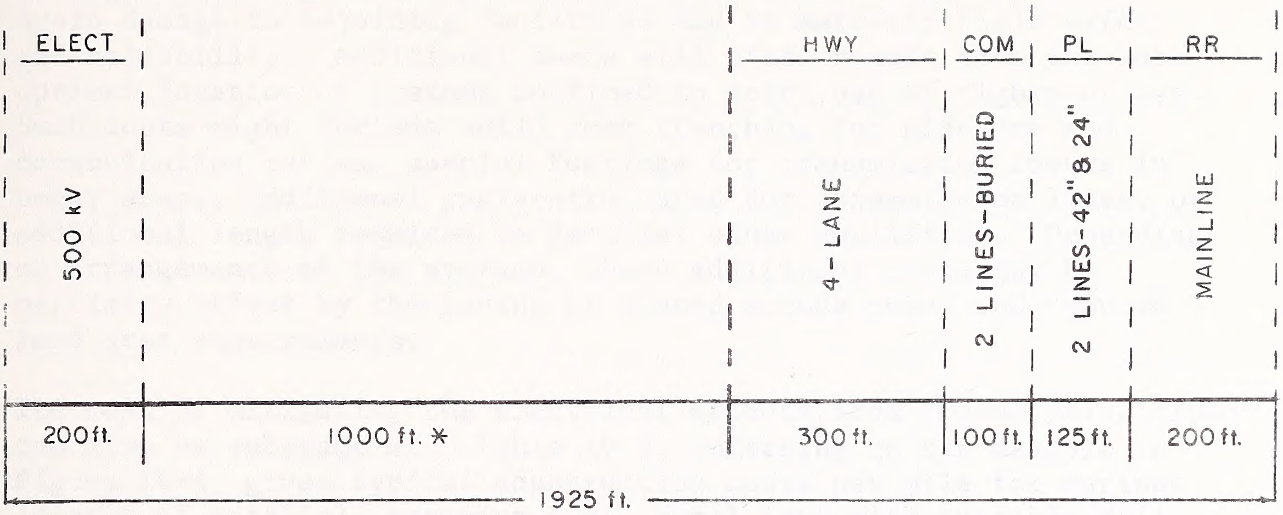
SYSTEMS INTERACTIONS IN JOINT USE OF RIGHTS-OF-WAY

Affected Systems / Influencing System	Electrical Transmission	Communications	Pipelines	Railroads	Highways
Electrical Transmission	Reliability degraded. Safety during maintenance from voltage gradient.	Steady state noise. Fault & lightning damage. Shock hazard. Corrosion of cable sheath. Construction damage.	Corrosion. Shock hazard. Fire/explosion hazard. Construction damage.	Shock hazard. False control signals. Fire hazard. Communications interference.	Radio noise. Audible noise. Fire hazard. Shock hazard.
Communications	Faults during construction.	Crosstalk. Cathodic protection interaction. Construction damage.	Cathodic protection interaction. Construction damage.	Construction damage.	Access interference.
Pipelines	Faults during construction. Fire/explosion hazard.	Cathodic protection interaction. Fuel leak damage/personnel safety. Construction damage.	Cathodic protection interaction. Fuel leak/fire and explosion hazard.	Construction damage. Fire/explosion hazard.	Access interference. Fire/explosion safety hazard.
Railroads	Derailment caused outage - reliability degraded.	Electrified RR's same problem as power. Derailment damage to repeater stations or above ground facilities.	Electrified RR's same problem as power. Derailment damage to valves, compressor or pumping stations, etc.	Reliability degraded due to possible accident. Safety degraded.	Safety degraded due to potential accidents. Access interference.
Highways	Reliability degraded due to accident related outages.	Damage to repeater station or above ground facilities due to vehicle accident.	Vehicle damage to above ground facilities due to accident.	Reliability degraded due to possible accident. Safety degraded	Safety degraded due to potential accidents. Access interference.

SOURCE: The Aerospace Corporation, 1975

FIGURE IV-3

JOINT USE - NO MITIGATION
(10 Mile Parallel)

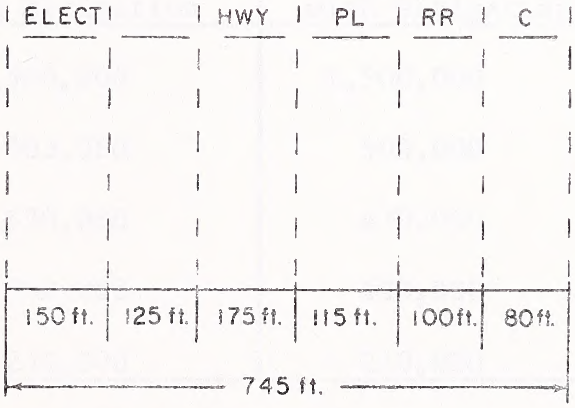


* In order to maintain no mitigation under adverse conditions and long parallels, this distance may be as great as 14,000 ft.

SOURCE: The Aerospace Corporation, 1975

FIGURE IV-4

JOINT USE - CONSIDERABLE MITIGATION
(10 Mile Parallel)



NOTE: These configurations have been used in this study for comparison purposes only. They have not been proven for applicability.

SOURCE: The Aerospace Corporation, 1975

c. Economic Considerations

Construction costs in joint use of rights-of-way will normally be higher because of the precautionary measures necessary to avoid damage to adjoining facilities and to maintain their safety and reliability. Additional costs will often result from the sub-optimal location of systems confined to joint use of rights-of-way. Such costs might include solid rock trenching for pipeline and communication cables, special footings for transmission towers in boggy areas, additional angle-structures for transmission lines, or additional length required to parallel other facilities. Depending on arrangements of the systems, these additional costs may be partially offset by the saving of shared access roads and reduced land area requirements.

The cost of mitigating the electrical effects from transmission lines can also be substantial. Table IV-3, referring to the example in Figure IV-4, gives typical construction costs per mile for various lengths of parallel, assuming flat, rural land with suitable soil conditions.

TABLE IV-3

CONSTRUCTION COST IN JOINT USE ($/Mile - 1974 Costs)

		10 Mi. Parallel	50 Mi. Parallel	100 Mi. Parallel
System	Base cost/Mi.	Cost with Mitigation	Cost with Mitigation	Cost with Mitigation
HWY	1,500,000	1,500,000	1,500,000	1,500,000
PL (2)	500,000	500,000	503,000	503,000
RR	600,000	610,000	630,000	630,000
COMM (2)	300,000	305,000	360,000	450,000
ELECT	220,000	230,000	230,000	230,000

NOTE: The systems listed above are of the same size shown in Figure IV-3.

SOURCES: The Aerospace Corporation, 1975 and Industry

d. Reliability

The placement of systems in close parallel tends to degrade service reliability for the systems involved. Examples of joint use related disruptions are:

1. Men and equipment working on one system damaging adjacent facilities;

2. A train derailment or highway accident damaging adjoining systems;

3. Explosion from a gas pipeline rupture damaging adjacent systems; or

4. An accident, sabotage, or natural disaster disrupting all systems in close proximity.

The term "reliability" takes on additional significance in the electric utility industry. Electrical systems must be designed to prevent cascading, widespread outages. The term "cascading" indicates a domino effect of circuit breaker tripping due to overloads or other causes until the transmission system is separated into small functioning islands or is completely de-energized. (The classic example of a cascading, widespread outage is the northeast blackout of November 1965.) If simulation tests indicate that the loss of adjacent transmission lines would result in a cascading outage, the adjacent location is unacceptable unless the system integrity can be enhanced by some other means.

Because of high circuit capacity now provided by our communications network -- up to as many as 230,000 circuits, a mix of service such as military, financial, TV, and general public, and the complexity of connecting arrangements -- any interruption of this service has a tremendous impact. Moreover, a cascading effect similar to that discussed earlier is always a threat: loss of one line may overload the capacity of alternate circuits and equipment, causing further disruption.

Gas pipelines, too, can fail, interrupting service to large consumer areas. If the gas supply is completely cut off to a local distributor, after the problem has been located and corrected, all service lines must be bled and all pilot lights relighted in order to restore service -- a time-consuming and expensive process.

Reliability for highways and railroads is established during the initial system design and maintained through material control, construction criteria, operating procedures, and adequate inspection and maintenance. Service reliability is important to these systems but in a sense is not as critical as for the utilities, where loss of one line can cause a widespread disruption. However, the transportation systems have rigid requirements for safety, and to the extent that reliability is achieved, a basis for safety is also achieved.

A factor which may influence all or any of the above systems is that construction and maintenance activities of joint-use right-of-way users increase the possibility of accidental damage to neighboring facilities. Adequate spacing between systems and cooperation and communication among users can minimize these risks but may increase costs.

3. Findings

- Adequate authority exists for the establishment of planning corridors on Federal lands.
- A national system of Planning corridors is feasible. However, the establishment of such a system requires an adequate information base and coordinated land-use planning, neither of which is adequate at this time.
- A Federal policy of preestablished joint-use corridors is not feasible, The extent of engineering problems, technical incompatibilities and reliability effects, and the associated design requirements, mitigative measures and costs cannot be determined prior to specific site evaluation.
- Joint use is feasible, provided that terrain, drainage, geology, and soils are suitable, and the systems are compatible or can be made so at a cost acceptable to society.
- Each right-of-way system has specific minimal requirements for construction space and operating space.
- Technical incompatibilities exist between systems operating in close proximity. Electric transmission lines are the major problem source.
- Joint-use costs will generally be greater than those of separate rights-of-way because of (1) special construction requirements, (2) suboptimal locations for some systems, and (3) mitigative measures.
- The placement of systems in close parallel tends to degrade their reliability.

C. Desirability of Corridors

In the feasibility assessment, it was determined that a Federal policy of nationwide preestablished joint-use corridors is not feasible. However, it was determined that planning corridors and individual determinations of joint-use rights-of-way are feasible.

Therefore, the following discussion treats first the desirability of planning corridors, then the desirability of joint use of rights-of-way.

1. Planning Corridors

a. Land-Use Planning Considerations

The planning corridor concept is predicated upon totally coordinated land-use planning -- the process in which systematic inventories are made to identify environmental and resource values, the conflicts between various uses or development thrusts are identified, and goals or objectives are established for protection of critical values and/or for guidance of development.

In effect, land-use planning seeks that blend of resource protection and development that is deemed socially acceptable and is based on maximum use of comprehensive information. This process charts a course for orderly and timely progress toward the stated objectives with a minimum of environmental and social impacts.

Planning corridors are a logical product of coordinated land-use planning because rights-of-way, by their linear nature, impact lands of different ownerships, resource values, and environmental quality. Land-use decisions affect resource development locations, industrial and utility plant sitings, and community expansions, which in turn directly influence the need and opportunity for utility and transportation rights-of-way.

There are land-use designations and classifications on Federal lands which affect the location of rights-of-way to varying degrees. Wilderness areas by law prohibit rights-of-way unless specifically approved by the President. National and State park systems restrict locating rights-of-way on lands designated as parks because rights-of-way generally conflict with the objectives of park management. Within wildlife refuges, wild and scenic rivers, some coastal zones, military reservations, and some Indian reservations, rights-of-way are obtainable, but only if they are, or can be made, consistent with the purposes for which the area was established.

There are other land areas which possess special values identified in the resource planning systems of the Forest Service and Bureau of Land Management. Management objectives are established for these land areas which may conflict with right-of-way use. Examples are: areas with scenic or open-space value; critical wildlife habitats, including those of rare and endangered species; fragile watersheds; and unique plant communities of scientific interest.

Right-of-way proponents are concerned that protected areas such as described above are increasing and may become barriers to future right-of-way use. Also, establishing such restricted areas may tend to force rights-of-way between or around them regardless of route suitability thereby compounding right-of-way problems. Therefore, all land uses, including linear right-of-way needs, should be fully considered before restrictive land-use decisions are implemented.

b. Environmental Considerations

The primary environmental benefit that planning corridors would achieve is the identification and avoidance of critical environmental areas. Critical wildlife habitats (including rare and endangered species protected by Public Law 93-205) and fragile ecosystems, where surface disturbance would result in erosion and other adverse ecological impacts, could be avoided. Areas of unique scenic beauty, areas of important food and fiber production, and open-space areas free from evidence of man's use can be established and maintained in concert with the identification of planning corridors. Further location of separate rights-of-way would be controlled to the extent warranted by specific conditions within a geographic area through the use of planning corridors. Decisions to locate rights-of-way outside planning corridors would require demonstrating that the planning corridor had been fully considered and that the public interest would be best served by a separate route.

c. Economic Considerations

Because planning corridors are dependent upon land-use planning, a brief discussion of the general costs and benefits of such planning is appropriate. Currently the Bureau of Land Management spends approximately 9 million and the Forest Service approximately 10 million dollars annually on resource and environmental inventories, evaluations, and the establishment of management objectives. Several bills have been introduced in Congress to fund and implement land-use planning. Three current proposals contain authorizations ranging from $300 to $800 million over a 5 to 8 year time period. The Department of the Interior in early 1975 estimated that an 8-year national land resource planning effort could be implemented with a grant program of 450 million dollars to the States.

Expenditures at this level would result in many social benefits not related to planning corridors. In particular, duplication of data gathering would be avoided, resulting in lower costs. The valuable data base obtained would be made available for the use of all interests seeking orderly and coordinated future developments, in addition to location of rights-of-way.

The primary economic benefits of planning corridors would come from allowing timely development of energy resources and the flow of products to consumers with a minimum of delay resulting from disputes over the location of rights-of-way. As secondary benefits, the data bank and land-use goals would also accelerate the NEPA process in the identification and assessment of rational alternatives when specific projects are proposed; the route with least environmental impact could be identified from the environmental baseline data gathered. Through coordination, planning corridors take into consideration right-of-way needs and seek to reserve areas from incompatible development or erroneous management decisions. This would provide an economic benefit for right-of-way users and would add a degree of certainty to their internal planning efforts.

This discussion of benefits is not meant to imply that public expenditures on land-use planning would be recovered through direct economic benefits from planning corridors. The greatest benefit would be the systematic gathering and analysis of information and the coordinated use of this information to minimize future environmental impacts and at the same time maximize national progress and development.

d. Social Considerations

The amount of coordinated land-use planning envisioned in the planning corridor concept may not be viewed as socially desirable by many segments of the public, particularly by private land owners in rural areas. It would be exceedingly difficult to implement without being viewed as increasing governmental control over individual property rights. Still, to many of those faced with impending development and change, a coordinated planning approach with full public participation might be preferred over the present separate right-of-way practices.

Planning corridors on Federal lands, as proposed, would offer an opportunity to demonstrate both the land-use planning process and the benefits to be gained from it. It would be a singular opportunity to enlist public cooperation and participation and to demonstrate that actions on Federal land would not inadvertently affect lands of other ownerships. Management and development objectives on all lands would be considered in the routing of future rights-of-way.

e. Coordination Considerations

To be effective, planning corridors must be a product of a coordinated effort among governmental agencies and private industry proposing energy development and ensuing right-of-way use. Office of Management and Budget Circular No. A-95 is a procedure for coordinating Federal and federally assisted programs and projects with each other and with State, regional, and local plans and programs. However, this coordinating mechanism is presently oriented toward completed plans and project proposals. The early planning coordination needed for planning corridors is not operating in all States. The levels of resource and environmental inventories are variable and stipulations or requirements of right-of-way practices vary between Federal Agencies and in some cases within each Agency. The coordination necessary in planning corridor development efforts would identify these conflicts in stipulations and assist in their resolution, while still maintaining policy flexibility to respond to differing environmental and resource management goals.

Resolving coordination problems is particularly difficult when interests conflict, hence controversies over specific projects are common. Planning corridors would offer a mechanism by which decisions to protect certain areas of environmental concern would be reached in a systematic process with the cooperation of government, industry, and the public. Public participation in setting land-use goals can be expected to encourage acceptance and support for the decisions reached.

2. Joint Use of Rights-of-Way

a. Land-Use Considerations

The concentration of facilities in a joint-use corridor leaves surrounding land areas free from right-of-way construction and conflicts and thus available for other uses. Such land-use efficiency is a primary benefit of joint use.

Of the utilities examined, pipelines using portions of established rights-of-way for part of their construction offer the best opportunity to use less land -- particularly pipelines adjacent to other pipelines. However, before placing a pipeline in the proximity of electric transmission lines, the trade-off between separation distances and mitigation costs must be assessed. Communication line rights-of-way can also be used by pipelines to reduce land commitment. Placing pipelines in the proximity of any other system (except highways) requires that the corrosion protection be coordimated. Highway and railroad rights-of-way, too, can readily be used for part of pipeline construction areas, but only when minimum levels of interference with traffic flow can be assured. Land use efficiency is also improved when two or more systems share a common access road.

Electrical interference problems discussed previously, also limit the opportunities for placing powerlines and other systems close enough to reduce land commitment. These problems are more difficult and expensive to solve if the buried systems are in place before a powerline is proposed. Consequently, preplanning and analysis of the spacing between systems and other mitigation measures are essential if interference levels are to be acceptable. And, particularly with powerlines, the spacing necessary to reduce electrical interference with other systems may obviate significant reductions in land commitment.

Further, the potential for system expansion must be considered in joint-use decisions. Highway and railroad widening, and future building of parallel pipelines and powerlines may limit the opportunities for land savings. Therefore, projections for all systems involved are important considerations in deciding joint-use configurations.

b. Environmental Considerations

Without specific situations, it is difficult to reach generalized conclusions about the environmental impacts of joint use. So much depends on the existing environmental characteristics of the area being considered for joint use and the other alternatives that decisions must be based on the specific project situation.

There are quantifiable reductions in land commitment and surface disturbance attributable to joint use which were described in the preceding paragraphs on land-use considerations. And, it is possible to state that one of the most important benefits from joint use is the avoidance of environmental impacts resulting from constructing another separate right-of-way. The primary justification for concentrating joint-use impacts in the joint-use area is to protect critical environmental areas by routing the systems around them.

However, this would not always be the best action relative to scenic considerations. Joint use tends to concentrate adverse impacts on scenic areas as can be seen in mountain passes and narrow valleys where several facilities have been forced together and dominate the landscape.

c. Economic Considerations

A decision for or against joint use would depend partially on the results of a cost comparison between alternate proposals covering an entire project length. Information required to make this comparison includes: basic design of systems involved, lengths, geology, soil, climate, accessibility, land cover (timber, etc.), land values and acquisition costs, construction costs, and compatibility between systems. Cost estimates are based on specific project data; however, some general observations regarding costs and benefits can be made.

(1) Joint-Use Costs

Increased costs resulting from joint use are in three basic categories:

- Total project costs;
- Construction costs, including mitigation; and
- Relocation costs.

Unless termini and other location determinants for the systems are identical, joint use requires additional length; thus increasing the total cost of the project. Industry cost data (using 1975 prices) for variable terrain, typical of lands in the Western States, indicate a 36" pipeline would cost approximately \$500,000 per mile and a 500 KV electric transmission line would cost about \$300,000 per mile.

Construction activity in close proximity to an existing system requires special methods and precautions to prevent damage to adjacent facilities and hazards to personnel. Costs of mitigating interference problems, too, can be substantial, particularly if an electric transmission system is involved.

In situations where small parcels of private land are involved, joint use by several rights-of-way increases the probability of relocating buildings or other improvements with attendant expenses.

(2) Joint-Use Benefits

The decision for or against joint use should be made only after cost estimates and environmental studies are completed because the decision often involves economic considerations vs. environmental and social impacts. It bears noting that the joint-use option will not always be the most costly, nor will it always be preferable from an environmental standpoint. Situations will arise where an economically desirable parallel location must be discarded in favor of more costly, but environmentally superior, separate rights-of-way.

Once the joint-use decision is made, however, there are some additional benefits to be gained in that the sharing of access roads may reduce costs, and frequently less right-of-way acreage is required. In addition, land clearing costs may be reduced because the new system(s) may be able to utilize part of an already cleared right-of-way.

d. Social Considerations

A decision to require joint use on Federal lands would, in most cases, dictate the location of the right-of-way on adjoining non-Federal lands. This may serve to concentrate adverse impacts on private land, and, if ownership of relatively small land parcels is involved, it could require total taking of properties and relocation of the residents and developments. Review and participation by all interested parties is needed to minimize uncompensated social inequities that accompany unilateral joint-use decisions.

Furthermore, private lands abutting or intermingled with Federal lands are often of different character than the Federal lands. For example, some private land in arid areas is adjacent to live water courses; agricultural land abutting Federal lands represents an abrupt change in land-use. And, some private lands have the potential for being subdivided into homesites. Consequently, taking these property rights for rights-of-way may limit the development potential of the private lands, hence this should be considered, along with legal ramifications, when making joint-use decisions.

e. Reliability Considerations

Joint use may reduce the reliability of the systems involved. The impact on reliability through disruption of service increases as distance between systems narrows. Maintaining uninterrupted service is an important goal of all systems, but particularly for electric, communications, and natural gas pipelines. Service disruptions in electrical systems and communications can cause system overloads in other portions of the network resulting in cascading outages. Pipeline systems also suffer when there is little or no storage or interconnection to other pipelines.

Where disruption of service by electric, communication, and pipeline systems can be demonstrated by simulation to have widespread and/or cascading effects and close systems proximity can be shown to increase the likelihood of disruption, joint use should allow sufficient space between systems or improved design to achieve adequate levels of reliability.

f. Safety Considerations

Joint use also increases opportunities for hazards such as electrical shocks and interference with normal traffic flow on highways and railroads. Safety during construction and operation must be provided in joint-use situations through adequate spacing between systems and adoption of stringent safety practices. To avoid safety problems, a free flow of safety information among systems engineers must be established prior to joint-use decisions. The degree of preplanning needed increases as the space between systems decreases.

g. Legal Considerations

Recent changes in legal authority for granting rights-of-way support the joint-use concept where feasible and practical. P.L. 93-153, amending section 28 of the Mineral Leasing Act of 1920, supports joint-use (common-use) practices for oil and gas pipelines by stating that:

> In order to minimize adverse environmental impacts and the proliferation of separate rights-of-way across Federal lands, the utilization of rights-of-way in common shall be required to the extent practical . . . (emphasis added).

The National Environmental Policy Act of 1969, in its required assessment of the environmental, economic, and social impacts of a project proposal, provides for an assessment of the alternatives, such as joint-use possibilities. The most recent legislative proposal for the Bureau of Land Management, cited as the "National Resource Lands Management Act," contains language directing the use of rights-of-way in common "to the extent practical."

Legal considerations of the utility and transportation industries concern, among other things, the control of the rights-of-way, financing, and liability considerations. An easement will provide sufficient property rights if complete control of all surface rights is not required for the safe and efficient operation of the system. A requisite of the easement is acquisition of sufficient property rights to control conflicting land use and practices without interfering with the construction and operation of the system. The right of access to and use of the right-of-way for maintenance is particularly important. Fee title is required when complete control of rights-of-way is needed, such as for railroads and highways where practically all other previous uses interfere with operation of the system.

The legal aspects of industry financing arise from the fact that investor-owned utilities raise the necessary capital for plant additions through a mix of debt and equity financing. In order to satisfy the requirements of the lenders, the utility must secure sufficient rights to certify that the facilities constructed will remain in place for an extended period of time without undue risk of having to abandon the location. Furthermore, control of the right-of-way in regard to other uses permitted is an important legal aspect in terms of determining liability in the event of a lawsuit. The complexities of joint-use situations would tend to complicate each company's control of its portion of the corridor in terms of financing and liability. In addition, a variety of questions involving legal rights can be expected concerning required joint use of the right-of-way.

By requiring joint use, Federal Agencies may be placed in a position of mediating compliance agreements among users: for example, disputes between companies over road maintenance responsibilities and cost sharing.

h. National Security Considerations

This study found that joint use increases the vulnerability of transportation and utility systems to acts of war. Review by modeling indicates that fewer nuclear or conventional weapons are needed to destroy a joint-use arrangement as compared to dispersed rights-of-way. (Aerospace Corporation, 1975)

Joint use, too, increases susceptibility to "bonus kill" through sabotage of one system resulting in disruptions to others. On the other hand, joint use would be easier to physically protect through surveillance, patrol, access control, or other measures.

The desirability of locating rights-of-way to protect the systems and reduce their vulnerability depends on the strategic importance of the systems and the specific situation.

3. Findings

° A national system of planning corridors is desirable. Implementation of a planning corridor requires the development of a complete data base, a land use plan, and coordination between all levels of government, industry, and the public.

° The desirability of joint use can only be determined for specific situations through identification and analysis of the variables involved and associated trade-offs.

° Early planning for future right-of-way locations is desirable because of proposed energy development projects and current trends in Federal land use and resource decisions that tend to limit right-of-way use.

° Coordinated and planned locations or proposed or projected rights-of-way across Federal land will minimize the loss of natural resources within or adjacent to the rights-of-way and avoid unnecessary environmental degradation.

APPENDIX A

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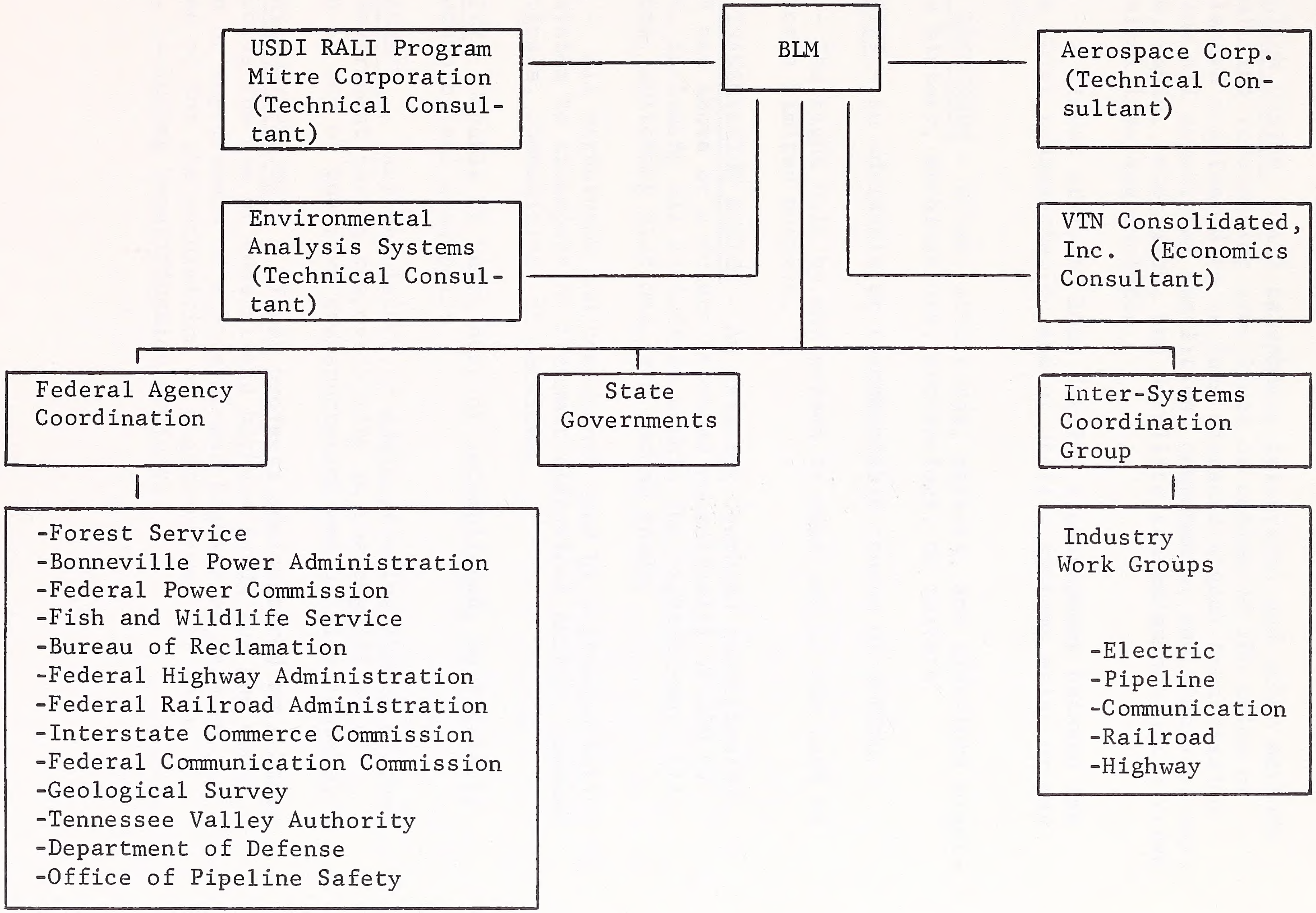
NOTE: Numerous other publications, periodicals, and references were researched in this study. The above lists only the principal data references referred to in this report.

APPENDIX B

TRANSPORTATION AND UTILITY CORRIDOR STUDY ORGANIZATION CHART


BLM
USDI RALI Program Mitre Corporation (Technical Consultant)
Environmental Analysis Systems (Technical Consultant)
Aerospace Corp. (Technical Consultant)
VTN Consolidated, Inc. (Economics Consultant)
Federal Agency Coordination
State Governments
Inter-Systems Coordination Group
-Forest Service
-Bonneville Power Administration
-Federal Power Commission
-Fish and Wildlife Service
-Bureau of Reclamation
-Federal Highway Administration
-Federal Railroad Administration
-Interstate Commerce Commission
-Federal Communication Commission
-Geological Survey
-Tennessee Valley Authority
-Department of Defense
-Office of Pipeline Safety
Industry Work Groups
-Electric
-Pipeline
-Communication
-Railroad
-Highway

APPENDIX C

GLOSSARY OF TERMS

COMMON USE - Same as JOINT USE

COMMUNICATION SYSTEM - All telephone, telegraph, and other methods of transmitting information over lines or cables of 100 miles or more in length considered to be long distance signal transmission lines, plus all associated facilities, components, and rights-of-way. Microwave, radio, television, and satellite transmissions not carried by a physical line are excluded.

CORRIDOR - A linear strip of land forming a passageway between two points in which transportation and/or utility systems exist or may be located.

CULTURAL RESOURCES - Sites, structures, objects, and districts significant in history, architecture, archaeology, or culture.

DESIRABILITY - An advisable or recommendable course of action.

EASEMENT - The right held by one person to make use of the land of another for a limited purpose.

ELECTRIC TRANSMISSION SYSTEM - An existing overhead powerline(s) of 115 KV and above or a future overhead powerline(s) of 230 KV and above, including all facilities within the right-of-way, all substations, switching stations, and access roads.

FACILITY - All structures and components used by a transportation or utility system to transport or transmit electrical energy, communication signals, commodities, or services.

FEASIBILITY - Capable of being done or accomplished, particularly from a technological standpoint.

FEDERAL AGENCY - Any regulatory or administrative branch of the Federal Government having responsibility in the regulation or operation of any of the five transportation and utility systems.

FEDERAL HIGHWAY PROJECTS - Those projects administered by a State which involve the use of Federal-aid highway funds for the construction or improvement of a Federal-aid highway or related facilities or for the acquisition of rights-of-way for such purposes, including beautification projects.

FEDERAL LANDS - For the purpose of this study, all lands owned by the United States except lands in the National Park System, lands held in trust for an Indian or Indian tribe, and lands on the Outer Continental Shelf.

FEE TITLE (relating to land ownership) - Transfer of all rights, title, and/or interest held by the grantor subject to any reservations the grantor may retain as specified in the granting document.

HIGHWAY SYSTEM - All roads designated as interstate or primary highways.

JOINT USE - Operating facilities of the same or different systems placed parallel to each other in as close proximity as practical. If more than one right-of-way is involved they may overlap entirely or partially, be adjoining, or separate.

JOINT-USE CORRIDOR - A narrow strip of land with restricted boundaries in which facilities of the same or different systems are placed adjacent to each other in as close proximity as practical and feasible.

JOINT USE OF RIGHTS-OF-WAY - Same as JOINT USE.

LAND-USE PLANNING - The process in which systematic inventories are made to identify environmental and resource values; the conflicts between various uses or management objectives are identified; and goals and objectives are established for protection of critical resource and environmental values and guidance of development plans and/or management objectives.

MITIGATE - To make less severe; attenuate.

NATIONAL SYSTEM OF TRANSPORTATION AND UTILITY CORRIDORS - Federal policy pertaining to highway, railroad, pipeline, electric transmission, and communication systems located or planned to be located across Federal lands.

NEED - An action deemed necessary in the interests of the Nation.

PIPELINE SYSTEM - Pipe, pumping stations, and all associated facilities needed to transport oil, gas, water, and coal between central gathering points and points of distribution.

PLANNING CORRIDOR - A broad linear strip of land, of variable width reserved between two geographic points, which has ecological, technical, and/or economic advantages over adjacent areas for the location of transportation and/or utility systems.

PROLIFERATION - Excessive, rapid spread.

PUBLIC DOMAIN - Original public lands which have never left Federal ownership; also, lands in Federal ownership which were obtained by the Government in exchange for public lands or for timber on such lands; also, original public domain lands which have reverted to Federal ownership through operation of the public land laws.

RAILROAD SYSTEM - All mainline railroad tracks of 100 miles or more in length, all rail extensions or additions of ten miles or more in length, and all associated facilities, components, and rights-of-way of all Class I railroads, with an annual revenue of $5 million or more, operating within the United States.

RELIABILITY - The combination of effects on a facility's capability to efficiently and effectively maintain continued service relevant to the probability and consequences of service disruptions.

RIGHT-OF-WAY - The legal right for use, occupancy, or access across land or water areas for a specified purpose or purposes. Such use on Federal land is authorized by permit, lease, easement, or license. On patented lands, it is acquired by easement or purchase.

SAFETY - Relative to the danger that may exist for sustaining property damage or personal injury.

SHARED USE - More than one use of the same or overlapping rights-of-way.

SYSTEMS - Individual and/or collective electrical transmission, pipeline, non-microwave communication, highway, and railroad facilities. These may consist of individual lines, routes, or facilities but for simplicity of discussion are referred to collectively. A system is not necessarily an interconnected network, though in many instances it is.

UTILITIES - Includes all privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communication signals, electrical energy, or petroleum and fossil fuel products.

WESTERN STATES - Those States located west of the 100th Meridian, including Alaska, but excluding Hawaii.

WHEELING - One utility company or agency transmitting electrical energy over the facilities of another company or agency.

BACKGROUND
AND
SUPPLEMENTAL DATA

The following sections contain background data and more detailed discussions to supplement the preceding summary report.

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SUPPLEMENTAL DATA

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V. DESCRIPTION OF FEDERAL LANDS

Federal lands constitute approximately 761 million acres or 33 percent of the nearly 2.3 billion acres of land area within the United States as shown in Table I-1. Approximately 94 percent of this Federal land is west of the 100th meridian. The areas administered by principal departments are indicated in the following table.

TABLE V-1

ADMINISTRATION OF FEDERALLY OWNED LAND
By Principal Departments
(As of June 30, 1973)

Department	Acres	Percent
Department of the Interior	539,153,326	70.8
Department of Agriculture	187,628,699	24.7
Department of Defense	30,616,140	4.0
All Others	3,601,008	0.5
TOTAL	760,999,173	100.0

SOURCE: Public Land Statistics, 1974, Bureau of Land Management, Department of the Interior

A. Department of the Interior

The Department of the Interior administers 70.8 percent of all federally owned land. The principal Agencies within the Department administering these lands are shown in Table V-2.

Table V-2

PRINCIPAL LAND ADMINISTERING AGENCIES
Within the Department of the Interior
(As of June 30, 1973)

Agency	Acres	Percent
Bureau of Land Management	473,783,564	88
Fish and Wildlife Service	28,082,782	5
Bureau of Reclamation	7,601,640	1
All Others *	29,685,340	6
TOTAL	539,153,326	100

*This includes the National Park Service and the Bureau of Indian Affairs which when combined administer approximately 5 percent of DOI lands. They are excluded from this study.

SOURCE: Public Land Statistics, 1974, Bureau of Land Management, Department of the Interior

1. Bureau of Land Management

The Bureau of Land Management (BLM) administers approximately 473.8 million acres of land in 23 States, 99.9 percent of which are in the Western States. This includes about 300 million acres in Alaska which will be reduced significantly in the near future as a result of State land selection entitlements and transfers of land to Natives under the Alaska Native Claims Settlement Act. Table V-3 lists the acreages administered in the Western States by the principal agencies.

Nearly all of the lands administered by BLM are public domain lands. These are lands that have remained in Federal ownership since they were acquired in the early history of the United States. As shown on the General Land Ownership Status Maps No. 1 and 2, BLM-administered lands cover a significant portion of the Western States. The ownership pattern is not as solid as the maps indicate, because there are large acreages of intermingled State and privately owned land.

TABLE V-3

ACRES OF FEDERAL LAND ADMINISTERED BY PRINCIPAL AGENCIES
AS OF JUNE 30, 1973

	FOREST SERVICE	BUREAU OF LAND MANAGEMENT	FISH AND WILDLIFE SERVICE	BUREAU OF RECLAMATION	CORPS OF ENGINEERS	ALL OTHERS	GRAND TOTAL
ALASKA	20,717,236	299,129,984	19,755,962	---	52,919	13,727,273	353,383,374
ARIZONA	11,434,616	12,586,620	1,537,201	1,059,970	33,643	5,281,969	31,934,019
CALIFORNIA	20,073,051	15,584,863	66,532	1,117,135	108,008	8,122,491	45,072,080
COLORADO	14,361,613	8,331,860	47,913	315,565	35,685	846,761	23,939,395
IDAHO	20,347,749	12,020,328	25,923	441,387	49,452	847,796	33,732,635
MONTANA	16,706,496	8,141,475	534,737	286,977	606,061	1,372,820	27,648,566
NEVADA	5,110,627	48,417,637	2,177,930	918,873	671	4,206,433	60,832,171
NEW MEXICO	9,227,016	12,948,952	94,323	198,420	15,454	3,383,097	25,867,262
OREGON	15,440,172	15,732,914	462,380	230,346	107,061	250,141	32,223,014
UTAH	8,051,000	22,641,481	97,882	1,305,495	---	2,769,802	34,865,660
WASHINGTON	9,067,944	301,591	123,701	407,746	103,353	2,571,291	12,575,626
WYOMING	9,274,897	17,543,151	44,431	865,444	---	2,339,741	30,067,664
WESTERN STATES	159,812,417	473,380,856	24,968,915	7,147,358	1,112,305	45,719,615	712,141,466
EASTERN STATES	27,411,996	402,708	3,113,867	454,282	6,529,389	10,945,465	48,857,707
TOTAL U.S.	187,224,413	473,783,564	28,082,782	7,601,640	7,641,694	56,665,080	760,999,173

SOURCE: Public Land Statistics, 1974, Bureau of Land Management, Department of the Interior

The public domain lands were typically less productive lands from an agricultural standpoint and generally were not homesteaded or otherwise patented as the country was settled. Most of the land is remotely located from major population centers and varies from low-lying deserts to high mountainous areas. Most of the Nation's oil shale reserves and much of the low-sulfur coal fields are located on these lands.

2. Fish and Wildlife Service

The Fish and Wildlife Service administers approximately 28.1 million acres of land throughout the Nation with about 90 percent being located in the Western States. The acreage in Alaska will undoubtedly increase significantly as a result of proposals for establishing new wildlife refuges under provision of the Alaska Native Claims Settlement Act.

Generally, the lands consist of disconnected acreages of variable sizes which are primarily valuable for wildlife, particularly waterfowl. The lands usually are not as remotely located as BLM- or Forest Service-administered lands.

3. Bureau of Reclamation

The Bureau of Reclamation administers approximately 7.6 million acres of which 95 percent are located in the Western States. These lands are involved with reclamation projects for agricultural irrigation and hydroelectric generation. They are composed of varying topography and generally used for compatible recreation purposes.

B. Department of Agriculture

The Department of Agriculture administers approximately 187.6 million acres of land of which the Forest Service has jurisdiction over 187 million acres.

1. Forest Service

Of the 187 million acres of land which the Forest Service administers in 44 States, approximately 160 million acres or 85 percent are located in the Western States. The acreage in Alaska is expected to increase significantly as a result of proposals for establishing new national forests under provisions of the Alaska Native Claims Settlement Act.

Most of the western national forests were established from public domain lands while the eastern national forests were established mainly from acquired private lands. The western national forest land pattern is in the form of relatively large solid blocks of Federal ownership and many of the national forests adjoin each other. Approximately 90 percent of the land within forest boundaries is in Federal ownership. Typically, the land administered by the Forest Service encompasses the most rugged topography in the United States.

Approximately half of the land within forest boundaries in the Eastern States is in private ownership which has a marked effect on program planning for and management of these lands. Most of the lands consist of cutover timber areas and abandoned farms located in mountains and uplands.

C. Department of Defense

The Department of Defense administers approximately 30.6 million acres of land, including military reservations of the Army, Navy, and Air Force. These lands were considered in the study, but it was found that use of them for transportation and utility systems involves a great many restrictions. Consequently, there is a tendency of right-of-way proponents to avoid, whenever possible, locating their systems across these lands.

1. Corps of Engineers

The Corps of Engineers administers approximately 7.6 million acres of land, 15 percent or 1.1 million acres of which are located in the Western States. Similar to Bureau of Reclamation-administered lands, Corps of Engineer lands primarily involve flood control, river, and reservoir projects which are suitable for agricultural, irrigation, and recreation purposes.

VI. INDIVIDUAL SYSTEM DESCRIPTION

A. Electrical

1. Historic Development of System

The establishment of Edison's steam electric station in New York City in 1882 marked the beginning of the rapidly developing electric power industry. Until the late 1880's, electricity was transmitted at low voltages by direct current lines. This limited the territory that could be served by a single electric power plant. Introduction of the transformer in 1886 led to the use of alternating current and higher transmission and distribution voltages, while improvement in generators and other equipment made possible larger output at lower unit costs.

As equipment became standardized, many small local companies consolidated into larger public utilities serving broader areas. During the 1920's, further consolidation occurred, and by 1932 about three-fourths of the output of all privately owned systems was generated by eight large holding companies. The reduced competition led to government regulations to insure electric power at reasonable rates for consumers. The Public Utility Act of 1939 gave the Securities and Exchange Commission authorization to regulate public utility and holding companies and to simplify the corporate structure of the electric and gas industries. Title II of this act authorized the Federal Power Commission to regulate wholesale electric rates in interstate commerce and to regulate certain aspects of corporate management, finance, and accounting.

In the 1930's, the construction of several dams, mainly for navigation and flood control purposes, led to direct Federal involvement in electric power generation and transmission. The Tennessee Valley Authority Act of 1933, authorized TVA to generate and market power in the Southeast. The Bonneville Act, enacted in 1937, established the Bonneville Power Administration as an Agency to market power from the federally constructed Bonneville Dam on the Columbia River and subsequently from other hygroelectric facilities in the Northwest. The Bureau of Reclamation, established by the Reclamation Act of 1902, was delegated authority to construct and operate generation and transmission facilities by several subsequent acts.

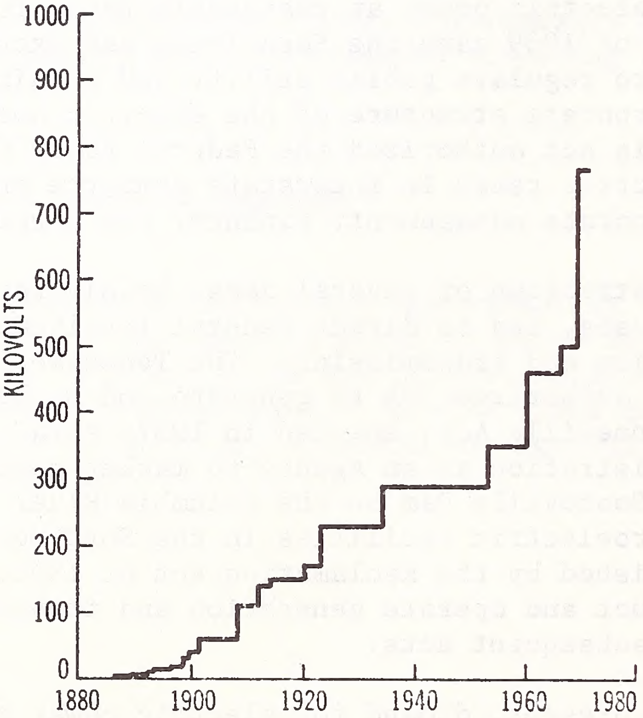
From the 1880's to the present, demand for electric power has increased at an average annual rate of about 7 percent, resulting in a doubling of demand about every 10 years. Since population growth has averaged about 1.3 percent annually during this period, the majority of increased electric power demand is attributed to growing per capita use.

In order to meet the rapid growth in demand for electric power, transmission systems have gone through a rapid evolution. First, a basic network was established and expanded. As loads increased, the trend was to higher and higher voltage levels. Most systems progressed from the 34.5 KV range to 115, 138, or 161 KV. Subsequently, these grids have been overlaid with 230 and 500 KV or 345 and 765 KV networks. In some systems, the larger voltage lines are used to transmit bulk power from a major generating source to a load center, then are stepped down to lower voltage for further transmission or distribution.

As the need for interconnections between companies increased, additional transmission capacity was required to provide ties between power pools and/or other operating areas. The most efficient method of increasing capacity has proven to be high voltage lines. This use of higher transmission voltages resulted in significantly reduced right-of-way needs. For example, a single 500 KV line will carry more power than four 230 KV lines.

FIGURE VI-1

MAXIMUM A-C VOLTAGE
IN USE 1883-1970



SOURCE: The 1970 National Power Survey, Federal Power Commission

2. Present System

Today the electrical power industry in the United States comprises approximately 3,500 utility systems, consisting of investor-owned, public non-Federal, Rural Electrification Administration Cooperatives, and Federal systems.

The investor-owned systems numerically make up approximately 12 percent of the industry. However, in terms of generating capacity and the number of customers served, these systems are by far the largest segment, providing over 75 percent of the generation and customer service. Because of the need to provide reliable service at a reasonable cost in an expanding market, more coordination and cooperation between investor-owned companies have taken place in recent years. They have formed power pools and joint ownership arrangements and have established reliability councils, planning organizations, and coordination groups. The increased coordination and cooperation among utilities also has often included public non-Federal and Federal systems.

Public non-Federal systems include municipalities, counties, special utility districts, and States. These systems sell about 13 percent of the total electric energy, the majority of which they generate themselves. The remainder is purchased from Federal systems and investor-owned systems. There are roughly 2,000 such systems, most of which are quite small in terms of annual sales.

The Rural Electrification Administration, established in 1936, has financed construction for about 1,000 cooperatives. These REA cooperatives account for only about four and one-half percent of the national energy sales. They purchase about three-fourths of their wholesale power requirements and generate the remainder.

The six Federal Agencies which market federally generated power are: The Bureau of Reclamation, Tennessee Valley Authority, Bonneville Power Administration, Southwestern Power Administration, Southeastern Power Administration, and Alaska Power Administration.

Federal marketing Agencies are required by law to give preference to public bodies and cooperatives in the sale of electric power. Hydroelectric power is generally less costly than that obtained from fossil fuel or nuclear generators. Consequently, Federal Agencies are able to deliver large blocks of low-cost firm power to their preference customers and they are able to sell interruptable power to industrial plants at attractive rates.

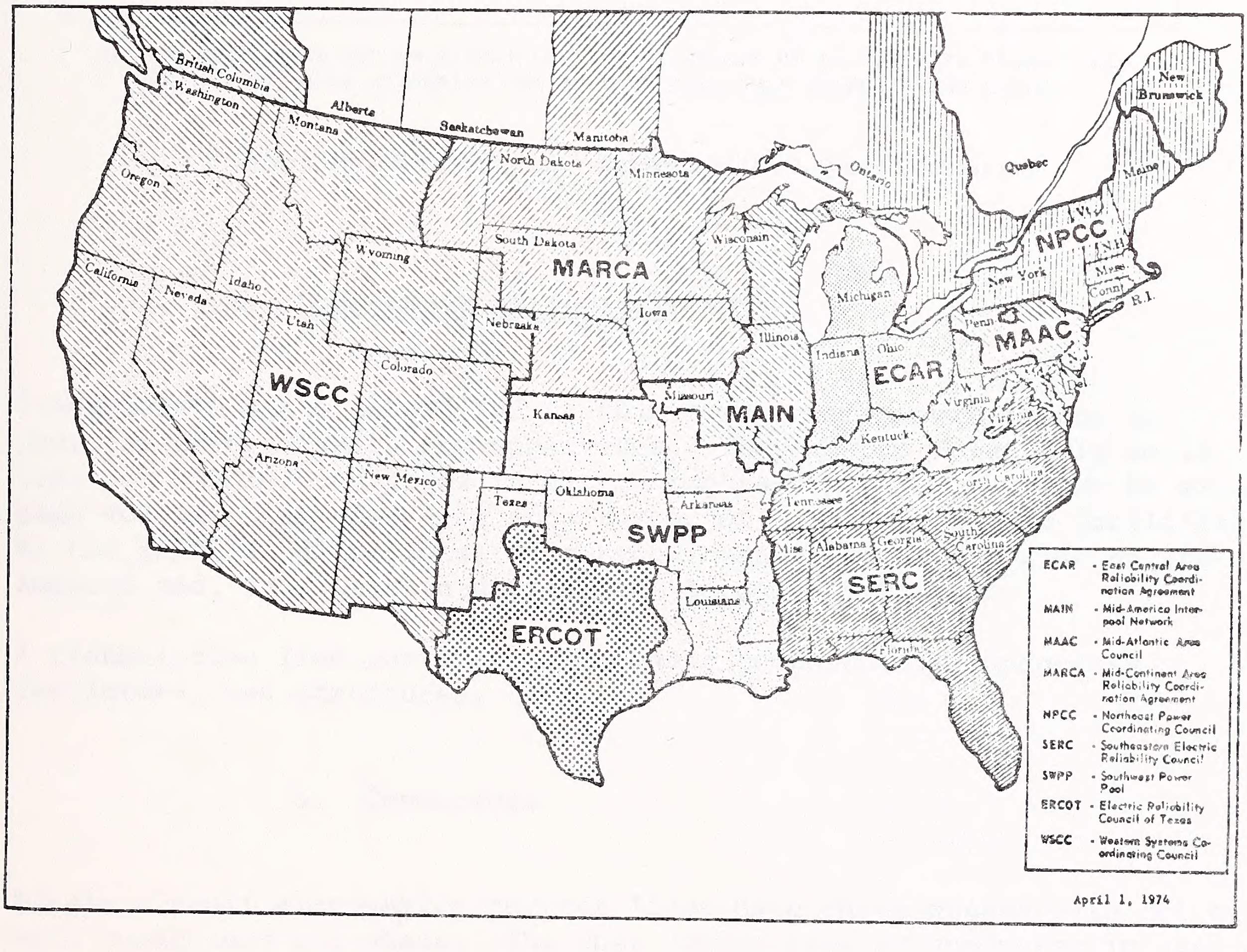
In 1968, the electric utility industry formed the National Electric Reliability Council. The primary mission of the NERC is, "To augment the reliability and adequacy of the bulk power supply of the electric utility systems in North America." NERC consists of nine regional

reliability councils whose membership comprise essentially all electric power companies in the United States and the Canadian Provinces of Ontario, British Columbia, Manitoba, and New Brunswick. The NERC and other formal and informal coordination groups have been very active in recent years because of the high degree of coordinated planning required to operate the many interconnected systems with efficiency and reliability.

The geographic areas covered by the nine reliability councils are shown in Figure VI-2.

FIGURE VI-2

REGIONAL ELECTRIC RELIABILITY COUNCILS



April 1, 1974

SOURCE: The Federal Power Commission

Transmission systems in the United States at 230 KV and above total about 110,000 circuit miles and are expanding rapidly. The following tabulation taken from the 1970 National Power Survey shows the breakdown according to voltage levels. Note the rapid increase in mileage and also the trend toward higher voltages.

TABLE VI-1

TRANSMISSION LINE MILEAGES IN U.S., 230 KV AND ABOVE[1/]

YEAR	230 kV	287 kV	345 kV	500 kV	765 kV	±400 kV(dc)	TOTAL
1940	2,327	647					2,974
1950	7,383	791					8,174
1960	18,701	1,024	2,641	13			22,379
1970	40,600	1,020	15,180	7,220	500	850	65,370
1980	59,560	870	32,670	20,180	3,540	1,670	118,490
1990	67,180	560	47,450	33,400	8,940	1,670	159,200

[1/] By 1990 there may be significant applications of ac voltages higher than 765 KV and more extensive use of HVDC than that shown in the table.

SOURCE: 1970 National Power Survey, Federal Power Commission

3. Components of Typical System

Transmission lines considered in this study cover a wide range in physical size, design, and appearance. They may be relatively small lines on single wood poles in narrow rights-of-way or they may be extra high voltage lines on steel structures, or even underground facilities. As the physical dimensions, appearance, and voltages vary, so do the impacts and, to a certain degree, the location criteria.

A transmission line contains three basic components: conductors, insulators, and structures.

a. Conductors

Single circuit alternating current lines have three phases with one or more conductors per phase. The most common type of conductor in use today is aluminum conductor-steel reinforced, consisting of a steel core around which aluminum wires are stranded. Conductors may be single or in bundles (two or more small conductors operating as one large conductor).

In addition to the three conductors (or bundles), many lines have ground wires above the transmission conductor, primarily for lightning protection. They provide a path to the ground through the tower steel, thereby avoiding surges through the conductor which could cause outages and/or damage to substation and switching equipment.

b. Insulators

An insulator is a bell-shaped object of nonconducting materials, such as porcelain, glass, or plastic used to suspend the conductor from the structure. Individual insulators are strung together in the length required by the voltage of the line.

c. Structures

Support structures generally fall into three categories: wood poles, steel towers, and "aesthetic" structures used in recent years, mostly in urban settings. A large variety of structure sizes and shapes are currently in use. The illustrations on the following pages depict some typical designs and configurations for each category.

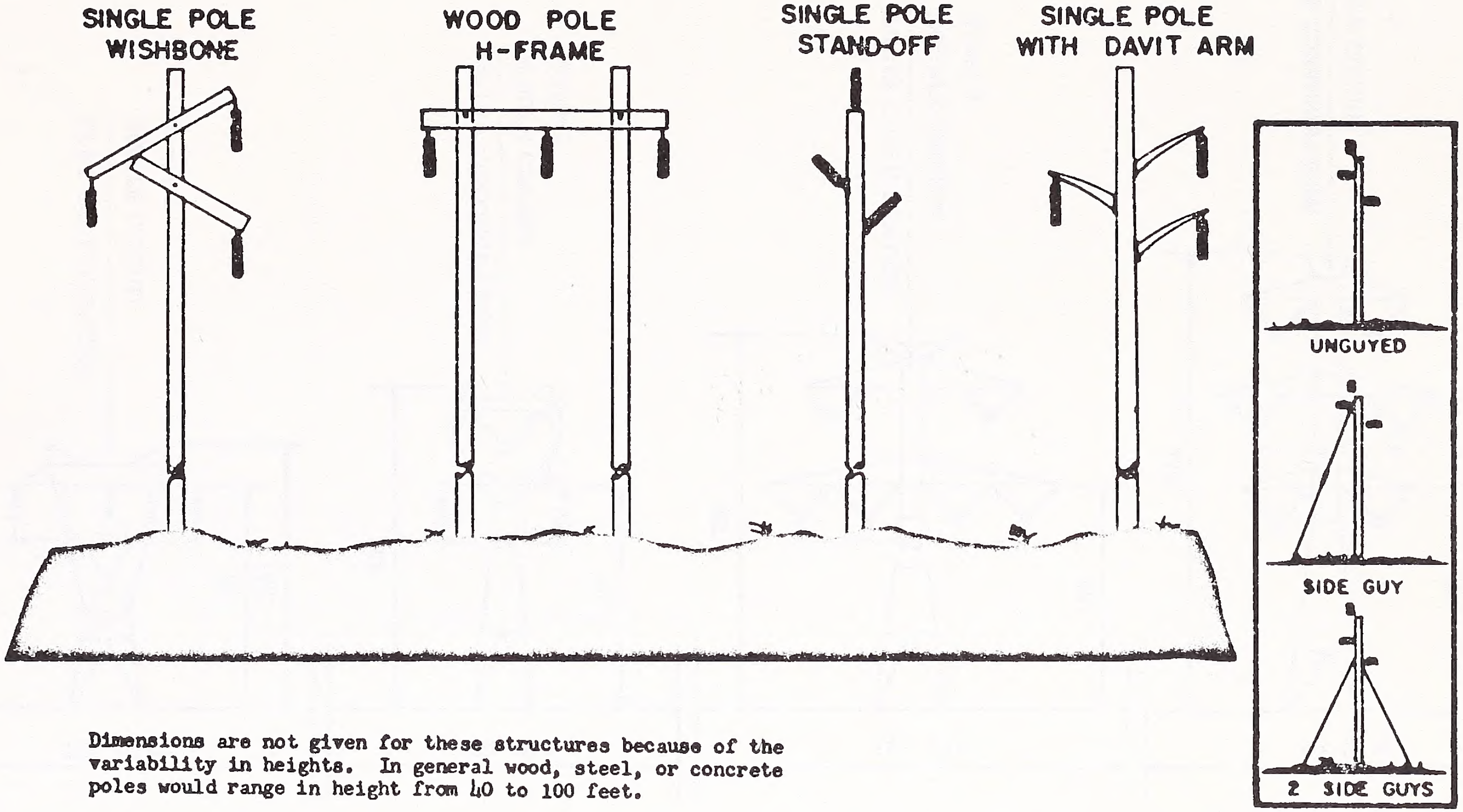
There are basically two types of transmission structures, "suspension" and "deadend." A suspension structure is commonly used on tangents and supports the weight of the conductor and loads caused by winds and ice. At bends in the transmission line, it is necessary to utilize a stronger deadend structure. The conductors are tied directly to a deadend structure through the insulator strings, rather than hanging beneath, therefore, it must withstand the tension of the conductors as well as their weight and the influences of climatic conditions. Sharp angles in transmission lines are avoided wherever possible because of the greatly increased cost of deadend structures.

Double circuit lines, consisting of two circuits supported by the same structures, are in common use. Because it carries two sets of conductors, a double circuit structure usually contains about the same amount of material as two comparable single circuit towers. The three phase conductors on each side are usually in a vertical configuration; therefore, these towers are taller.

The span length (spacing between structures) is a compromise of several factors. Obviously with stronger conductors and stronger, taller structures, greater span lengths can be obtained. The cost and aesthetic impact of larger structures must be weighed against the cost and impact of a greater number of small structures. Average span lengths for single pole wood structures are 250 to 400 feet. H-frame wood structures average 700 to 900 feet, while lattice steel structures at most common

FIGURE VI-3

CONFIGURATION OF TYPICAL
115 KV WOOD TRANSMISSION POLES

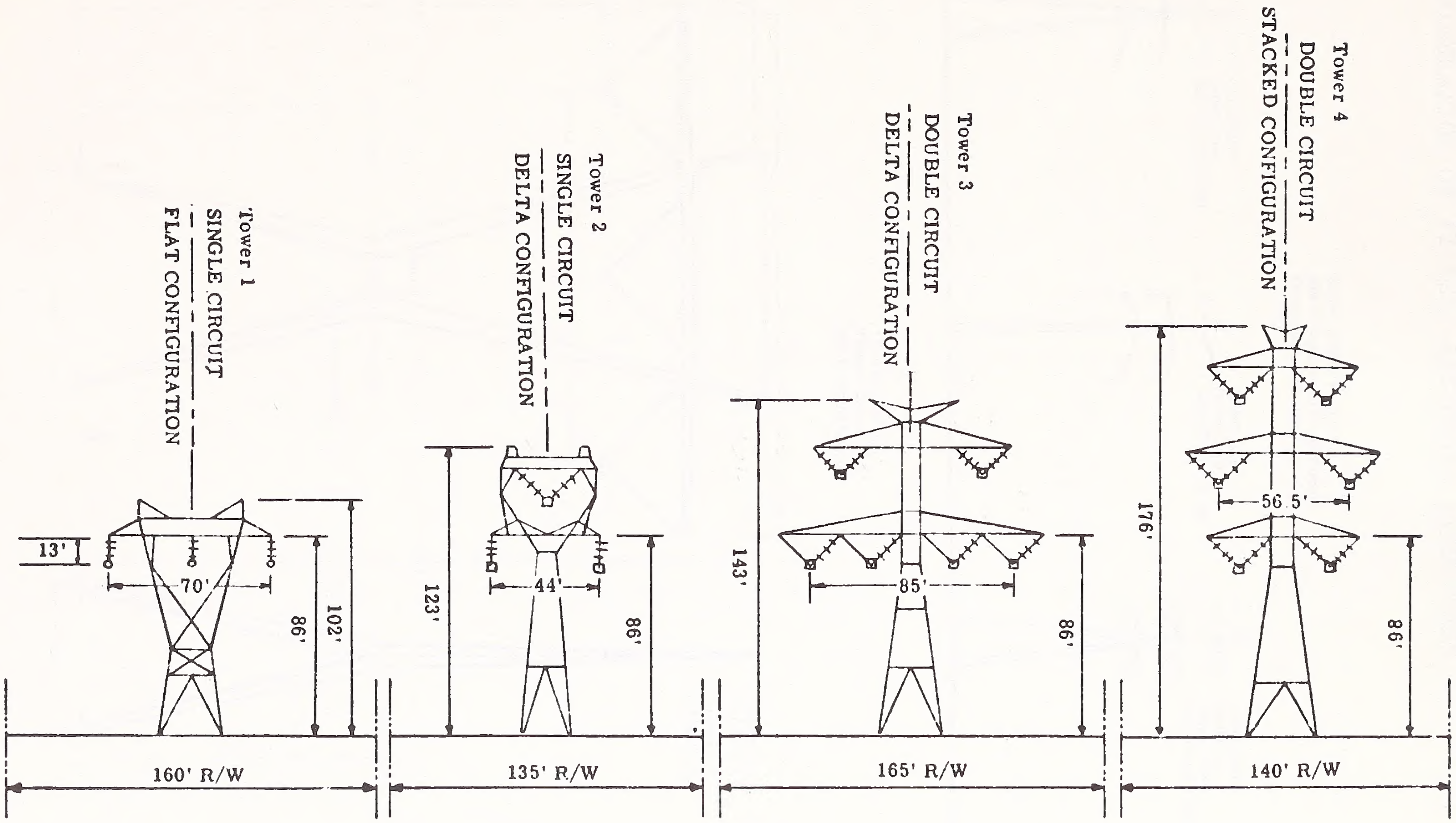


Dimensions are not given for these structures because of the variability in heights. In general wood, steel, or concrete poles would range in height from 40 to 100 feet.

SOURCE: Bonneville Power Administration

FIGURE VI-4

CONFIGURATION OF TYPICAL
500 KV METAL TRANSMISSION TOWERS

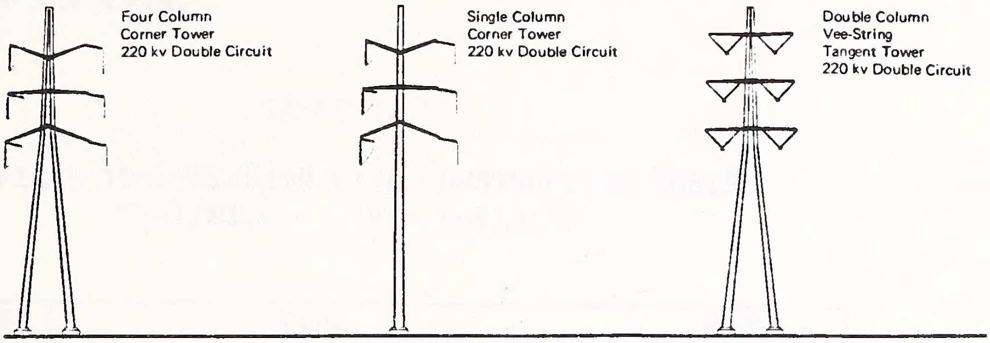


SOURCE: Bonneville Power Administration

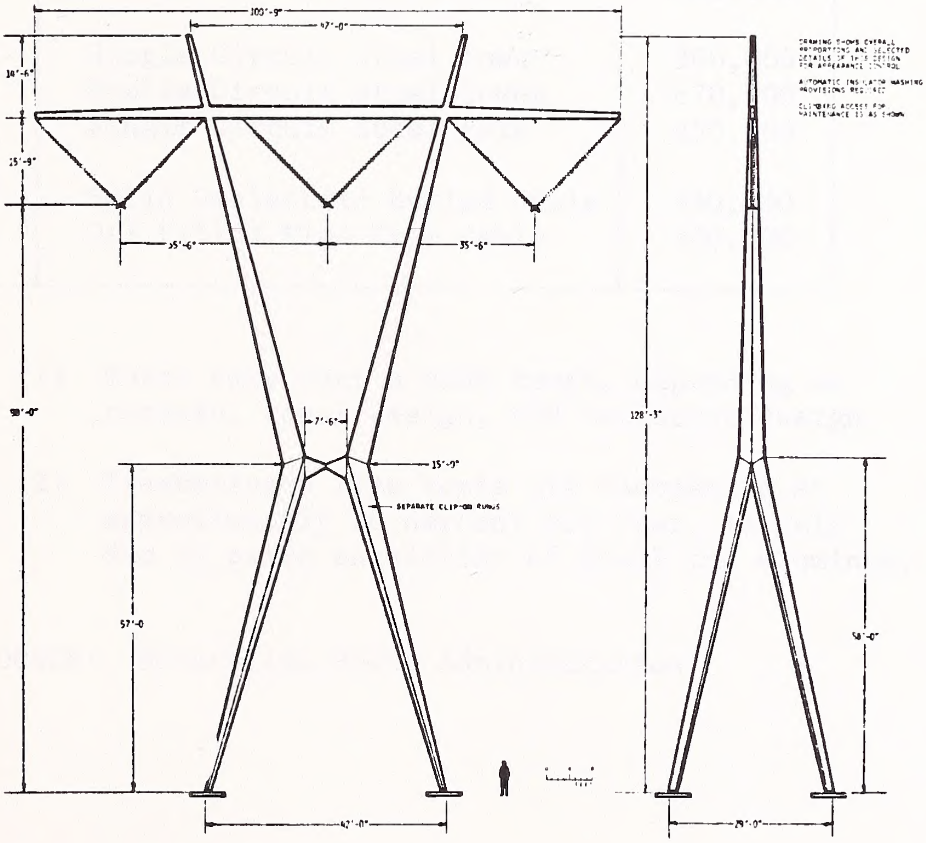
FIGURE VI-5

CONFIGURATION OF TYPICAL AESTHETIC STRUCTURES

Contemporary Family
220 kv Double and Single Circuit
Transmission Structures



Tetra Box Section
Tangent Tower
500 kv Single Circuit



DRAWING SHOWS OVERALL PROPORTIONS AND SELECTED DETAILS OF THIS DESIGN FOR APPEARANCE CONTROL

AUTOMATIC INSULATOR WASHING PROVISIONS REQUIRED

CLIMBING ACCESS FOR MAINTENANCE IS AS SHOWN

SOURCE: Southern California Edison

voltages are about 1,100-1,500 feet apart. Average spans are obtained only where the ground profile is relatively level. For example, crossing a rounded ridge may require several structures, while a sharp ridge may only require one. Long spans can be obtained crossing deep draws and valleys.

Electric transmission lines require significant capital investment in order to deliver energy at low unit costs. Listed below are some typical transmission line cost data for 1974. These figures include total costs involved.

TABLE VI-2

TYPICAL TRANSMISSION LINE CONSTRUCTION COSTS
Cost/Mile - (1974 Dollars)

VOLTAGE	TYPE	COST
230 KV	Wood pole, "H"-frame	$100,000
230 KV	Single Circuit Steel Tower	130,000
230 KV	Double Circuit Steel Tower	200,000
230 KV	Double Circuit Steel Pole	300,000
500 KV	Single Circuit Steel Tower	300,000
500 KV	Double Circuit Steel Tower	670,000
500 KV	Single Circuit Steel Pole	450,000
115 KV	Solid Dielectric Buried Cable	450,000
230 KV	Oil Filled Pipe Type Cable	900,000

NOTE: (1) Costs vary over a wide range, depending on terrain, tower design, and conductor design.

(2) Transmission line costs are increasing at approximately 20 percent per year, largely due to price escalation of steel and aluminum.

SOURCE: Bonneville Power Administration

4. Anticipated Developments

a. Industry Development

An industry projection for future needs in the Western States is contained in a report by the Western Systems Coordinating Council entitled "Western Systems Coordinating Council Ten Year Coordination Plan Summary 1974-1983." A large majority of the Federal lands in the contiguous United States lie within the WSCC region.

The following table is derived from the WSCC Ten-Year Plan.

TABLE VI-3

10-YEAR PROJECTION - TRANSMISSION LINES (WSCC-AREA)

VOLTAGE	CIRCUIT MILES OF TRANSMISSION LINES			
	12-31-73	ADDITIONS* 1974-1983	1983	% increase
115-161 KV	30,163	915	31,078	3
230 KV	25,753	4,668	30,421	18
287-360 KV	3,648	4,935	8,583	135
500 KV	6,594	9,204	15,798	140
800 KV	844	816	1,660	97
TOTAL	67,002	20,538	87,540	31

* WSCC projections only include "Significant additions," which either (1) provide ties to the interconnected system from major generation sources, (2) are ties between central areas, or (3) are significant to an overlay pattern.

SOURCE: Western Systems Coordinating Council

It can be seen that substantial additions to the 230 KV, 345 KV, and 500 KV systems are now planned. These proposed transmission lines are shown on Map #5, "Electric Power Transmission System. The Western Systems Coordinating Council discusses this projection in their report with the following statement:

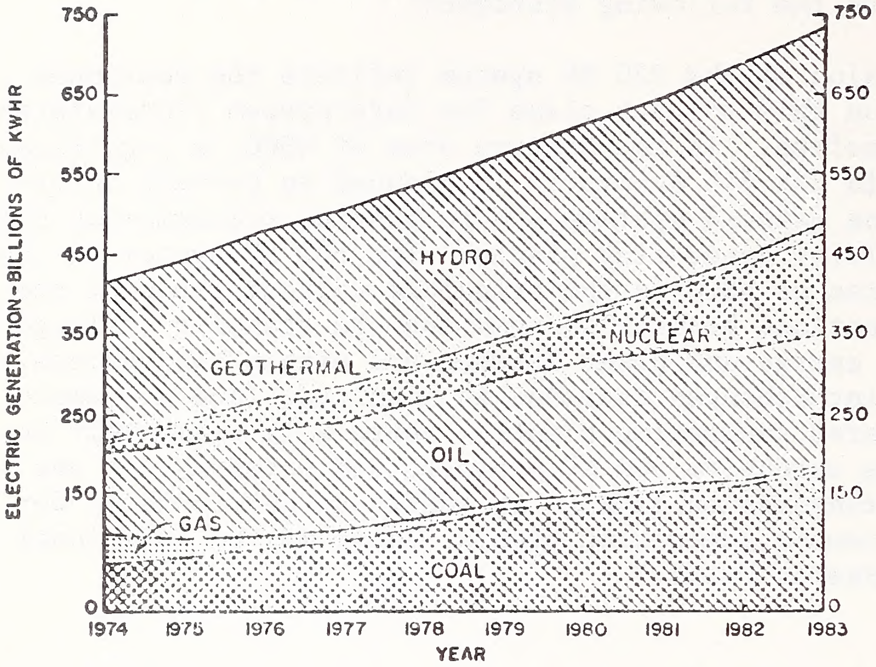
> "The expansion of the 230 KV system reflects the continued reliance on this voltage class for intersystem (interstate) power transfers. In the Eastern area of WSCC, a significant increase in the 345 KV system is planned to provide interconnections between systems and to provide transmission outlets for large generating plants. The 500 KV system in the Western area of WSCC is the principle voltage class of the interconnections between systems and the transfer of large blocks of energy and power between and within the systems. As these interchanges increase in magnitude (due to remote and/or shared generating plants), there will ultimately be a still more extensive 500 KV network, and possibly the use of the UHV transmission lines. In addition, particularly for possible remote generating plants, there may be additional DC transmission built."

b. Demands

The historic doubling of consumption every 10 years is expected to decline slightly in the 1980's. The WSCC projects for its region an average compound growth rate of 6.7 percent in winter and 6.8 percent in summer for the period 1974 to 1983. If the United States were to adopt stringent energy conservation measures, these figures could be reduced somewhat. The Federal Energy Administration's Project Independence report indicates a national 4 percent growth rate is possible. In any case, future growth will be significant. The energy sources of electric generation to meet these demands is projected by the WSCC in figure VI-6. Note that the greatest increase is in nuclear generation and coal fired thermal-generation. Both types typically require sizable transmission systems. This is particularly true for coal, since the known reserves are generally a great distance from major load centers.

FIGURE VI-6

TOTAL WSCC ELECTRIC GENERATION - BY SOURCES
AVERAGE HYDRO CONDITIONS



SOURCE: Western Systems Coordinating Council

c. Legislation

Several States have enacted facility siting legislation and it is likely other States will follow suit within the next ten years. It is difficult to anticipate the effect of ensuing legislation on transmission lines until such legislation is passed. Some States will undoubtedly pass acts which give strong authority and responsibility for locating transmission lines to State governments. Other States are moving in the direction of land-use planning legislation which delegates the actual control of facilities to the local entities such as county and regional planning commissions. In any event, it can be expected that much tighter control over facility locations will be exercised at some level of Government.

d. Technological Advances

Most transmission facilities planned for energization within the next ten years will be constructed using present technology. However, a considerable research effort is being expended in this field. Technological advances which may affect the electrical transmission situation in the not too distant future include UHV (ultra high voltage) overhead transmission, underground transmission, and DC (direct current) systems.

The continuing rapid increase of electricity consumption; construction of larger, more economical generating units; and pressures to limit new rights-of-way are forcing a continuing upward trend of primary transmission voltage. UHV (1,000 KV or higher) transmission lines are expected to be needed by the 1980's. The voltages under consideration are 1,100 to 1,200 KV as an overlay for existing 500 KV systems, and 1,500 KV or higher as an overlay for 765 KV systems. A number of research projects leading to the design of UHV systems are underway in the United States, Canada, Europe, and Russia. These projects address electrical and mechanical problems, both of which increase in complexity with voltages above 765 KV.

UHV transmission will affect rights-of-way in two ways. First, the total right-of-way acreage required to transmit a given amount of electricity will be less because of the much greater capacity of UHV lines. Secondly, the impact on a right-of-way is magnified because of large structures required. A proposed 1,100 KV design would have towers 200 feet high, as compared to 125 feet for similar type 500 KV towers.

To date, underground power transmission has been used primarily for distribution lines of lower voltage levels. A limited amount of underground transmission in the voltage range above 115 KV has been constructed, mainly in densely populated urban areas. A total of 197 miles of underground transmission lines, 230 KV and above, was in service on June 30, 1974. More than 99 percent of all underground transmission in the United States is composed of some variant of paper-tape, oil-insulated cable, either directly buried or enclosed in steel pipes. Extruded solid dielectric cables used widely for distribution voltages have been extended to EHV in recent years. The processes of manufacture and installation of solid dielectric cables are relatively simple, compared to other types, but the reliability record of installed systems at EHV levels has been poor.

Compressed gas insulated cables have been installed in sections a few hundred feet long for up to 500 KV. This type of underground system has a high current rating and very high power carrying capacity as compared to the paper tape or solid dielectric cables. Compressed gas insulated cables show promise for long distance transmission although present applications have been limited to short installations.

"Cryogenic" systems operate at very low temperatures in order to exploit the fact that the electrical resistance of a metal diminishes as its temperature is lowered. Two types of cryogenic systems are under development in the United States: "Cryoresistive," in which the resistance of the metal remains finite although it is considerably below its value at room temperature, and "superconducting," in which the resistance of the material becomes essentially zero as the temperature approaches absolute zero.

Neither of these cryogenic systems are expected to be fully developed and used before 1985. The estimated cost of cryogenic systems is extremely high. For example, a 138 KV cable transmitting 3,400 megawatts is expected to cost over $2 million per mile.

Direct current transmission has some advantages over alternating current: 1) lower power loss for given line resistance, 2) the absence of the effects of the reactive impedence in the line, and 3) lowered overhead line construction cost. These advantages are offset by the requirement for expensive AC/DC conversion equipment at each end of the DC line. As a result, DC transmission lines are only economically feasible for long distances, generally 400 miles or greater. Approximately 1,600 miles of DC transmission lines are planned between now and 1985. As the need for stronger interties between sections of the country becomes greater, there will undoubtedly be more DC transmission during the late 1980's and 1990's.

B. Pipelines

Pipeline system functions are categorized as: gathering, transmission, and distribution. Gathering pipelines collect from diverse sources such as each well within an oil or gas field and then converge into a transmission pipeline or trunk line that transports the aggregated product to a refinery or other major collection point. From there, distribution pipelines deliver to such diverse points as individual consumers.

Long distance "slurry" pipelines are also used to transport solids such as finely ground coal suspended or emulsified in water.

There are technical, economic, and regulatory differences in systems, depending on the commodity being moved. Pipelines gather, transport, and distribute crude oil and natural gas. Refined products from crude oil are transported from refineries to distribution points.

This discussion excludes municipal water delivery systems which are usually huge concrete pipes in conjunction with covered and open canals. The study does, however, discuss the important features that affect right-of-way use by all products moved through steel pipe within specified size parameters. Emphasis is on the transmission function because transmission pipelines offer the best opportunity for evaluating the feasibility, desirability, and need for transportation and utility corridors or joint use of rights-of-way.

1. Historic Development of Systems

The growth of pipeline systems has closely paralleled growth of the petroleum industry due to the nature and location of the products: oil and gas deposits are spread over a large area, frequently quite remote from refineries and markets. The problem of distance between source and end-use had to be overcome before the petroleum industry could develop.

a. Crude Oil and Refined Products

A combination of wagons and boats delivered crude oil from the first oil well drilled in 1859, near Titusville, Pennsylvania, to a refinery 11 miles away. A short time later new refineries at Pittsburgh, about 75 miles from the first oil field, received crude oil the same way. Up to 1,000 boats of all sizes were used and at one time up to 2,000 teams pulled oil wagons through Titusville each day. Wooden tanks on railroad cars were also used as rail service became available. Hazards, congestion, and high shipping fees demanded by teamsters and railroads stimulated a more economic and safer form of transportation, resulting in the use of pipelines.

Leaks in cast iron pipes, damage by irate teamsters, and legal difficulties with railroads were major problems to early pipeline systems. With the advent of wrought iron pipe, some of the technical problems were removed. Through the 1860's and 70's, pipelines delivered crude oil to refineries at less than half the cost of wagon transportation. After winning a lengthy court battle in 1875 reestablishing the legal right for pipelines to cross a railroad right-of-way, a 3-inch pipeline delivered 500 barrels of oil per hour at a cost of $0.30 per barrel for a distance of 60 miles. Subsequent pipelines were larger and longer. Competition resulted in lower railroad rates which placed the production of oil on a more equal footing with the transportation and refining sectors of the emerging petroleum industry.

As Appalachian oil fields were depleted in the early 1900's, refineries serving eastern industrial and population centers began to draw from distant western and southwestern oil fields. Continued growth necessitated new refineries near the Great Lakes, Mississippi River, and the Texas Gulf and California coasts. Improvements in welding, use of steel pipe rather than wrought iron, and increases in pump size and reliability enabled pipelines to contribute to the movement of products.

The depression years of the 1930's forced new economies of product distribution between refineries and consumers. Pipelines again served as the lowest cost method. In 1930-31, 3,000 miles of product pipeline capable of transporting separate grades of refined products were built.

Until the States exerted controls on rates of production and spacing between wells, pipelines were constructed to oil fields at frantic speed. Wells that could deliver their product the quickest could drain oil from neighbors. The first pipelines into a field could also attract shipments from other wells since it was cheaper and quicker to expand capacity by paralleling existing lines rather than building on a new route. Thus, speed was important, if not paramount.

World War II temporarily halted ship and barge transport of crude oil and associated products from the Gulf Coast to the East Coast. The war effort petroleum demand in the industrialized East caused dramatic increases in pipeline size and length. Using Federal financing and emergency authority to acquire a right-of-way, the first 16" crude line 385 miles long and two product lines 24" and 20" both well over 1,000 miles long were constructed as part of the war effort.

Pipelines are now the principal means of transporting oil, carrying about 57 percent. The remainder is moved by tanker and barge with minor amounts by rail and truck.

b. Natural Gas

In the early 1900's, short pipelines were used to distribute manufactured gas in both Europe and the United States. Until the 1940's, natural gas was, for the most part, an unwanted byproduct of crude oil production. Markets were few and of necessity, close to producing areas. Even as late as 1945, the common practice was to flare or burn gas in or near the oil fields. Natural gas has grown from a waste product to one that furnishes over one third of the total energy consumed. Total miles of gas pipeline tripled from 1945 to 1971. For all practical purposes, pipelines transport all natural gas.

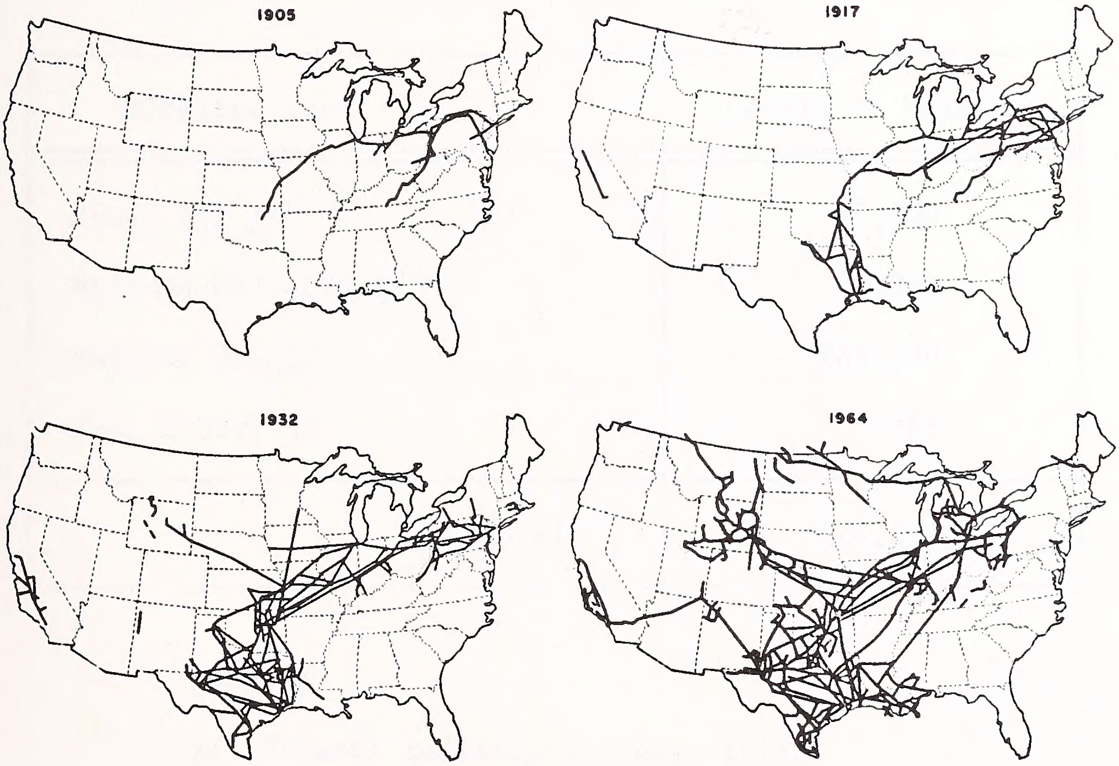
As with oil pipelines, increased pipe diameter up to 42 inches, combined with increased pipeline length, made large quantities of natural gas available in nearly all areas of the country. Artificially low wellhead prices under regulation gave the economic incentive for increased use of this clean burning fuel. Gas is now sought as a separate resource and three-fourth of the gas comes from wells not associated with oil production.

The growth in pipe diameters and fairly standard pipe section lengths of 40 and 80 feet required larger equipment to dig the trench and lay pipe. Need for reliable delivery and safe operation led to increasingly sophisticated protection of pipelines from corrosion. These factors, pipe size and access requirements for maintenance and testing corrosion protection facilities, directly affect the size of the right-of-way needed.

Figure VI-7 illustrates the growth of the crude oil transmission system. Natural gas and products pipelines have a similar pattern of east to southwest and east to west development.

FIGURE VI-7

GROWTH OF CRUDE OIL PIPELINES IN THE UNITED STATES



SOURCE: Petroleum Extension Service, The University of Texas

c. Coal Slurry Pipelines

The first patent for pumping coal in water was issued in 1891. With successful operation of the 18-inch, 273-mile Black Mesa, Arizona, coal slurry line in 1970 and other slurry lines around the world, the economic and technical feasibility of this technique for transporting coal has been proven.

2. Present System

Map #6 showing the location of the oil, refined products, and natural gas transmission systems is found in the appendix. The following table indicates the length of crude and product trunk lines and natural gas transmission lines. Gathering and distribution pipelines are not included.

TABLE VI-4

TRANSMISSION PIPELINES IN THE U.S.

Pipeline Type	Length in Miles
Crude Oil 1/	76,250
Refined Products 1/	76,839
Natural Gas 2/	265,200
Coal Slurry 3/	381
Total	418,670

SOURCES:

1/ Mineral Industry Surveys, 1974
2/ Gas Facts, 1973
3/ Energy Transmission Systems Inc., 1974

The following table shows total transmission capacities:

TABLE VI-5

PIPELINE TRANSMISSION CAPACITIES

PRODUCT	AMOUNT
Crude Oil (42 gallon barrels) 1973	5.4 billion 1/
Products (42 gallon barrels) 1973	3.6 billion 1/
Natural Gas (millions of cubic feet) 1973	56.9 million 2/
Coal (tons)	6.1 million 3/

SOURCES:

1/ Transportation Statistics In The United States, PT.6, ICC.
2/ Gas Facts, 1973 American Gas Association
3/ Energy Transmission Systems, Inc.

Table VI-6 shows the nationwide average construction costs of pipeline in 1973-1974. Industry representatives indicate that for long pipelines in mixed terrain typical of the Western U.S. costs are projected to be as much as five times more than these averages. Current estimates for the northern border pipeline exceed $1 million per mile for a 42" natural gas pipeline. Other estimates up to $500,000 per mile for 24" petroleum pipelines are being used. Table VI-6 indicates the approximate spread of costs across construction components.

TABLE VI-6

PIPELINE CONSTRUCTION BASED ON 1973-1974 COSTS

Size	R O W	Material	Labor	Misc.	Total Cost/Mile
8 inch	1,504	11,785	19,242	1,599	$ 34,130
12 inch	2,400	18,570	28,385	2,725	52,080
16 inch	2,251	22,464	32,020	10,135	66,870
20 inch	6,356	49,152	98,168	14,712	163,388
24 inch	3,944	53,295	29,764	13,047	100,794
30 inch	9,766	98,123	64,677	21,706	194,289
36 inch	7,350	121,715	79,025	24,551	232,641

SOURCE: Oil and Gas Journal, August 12, 1974

3. Components of Typical System

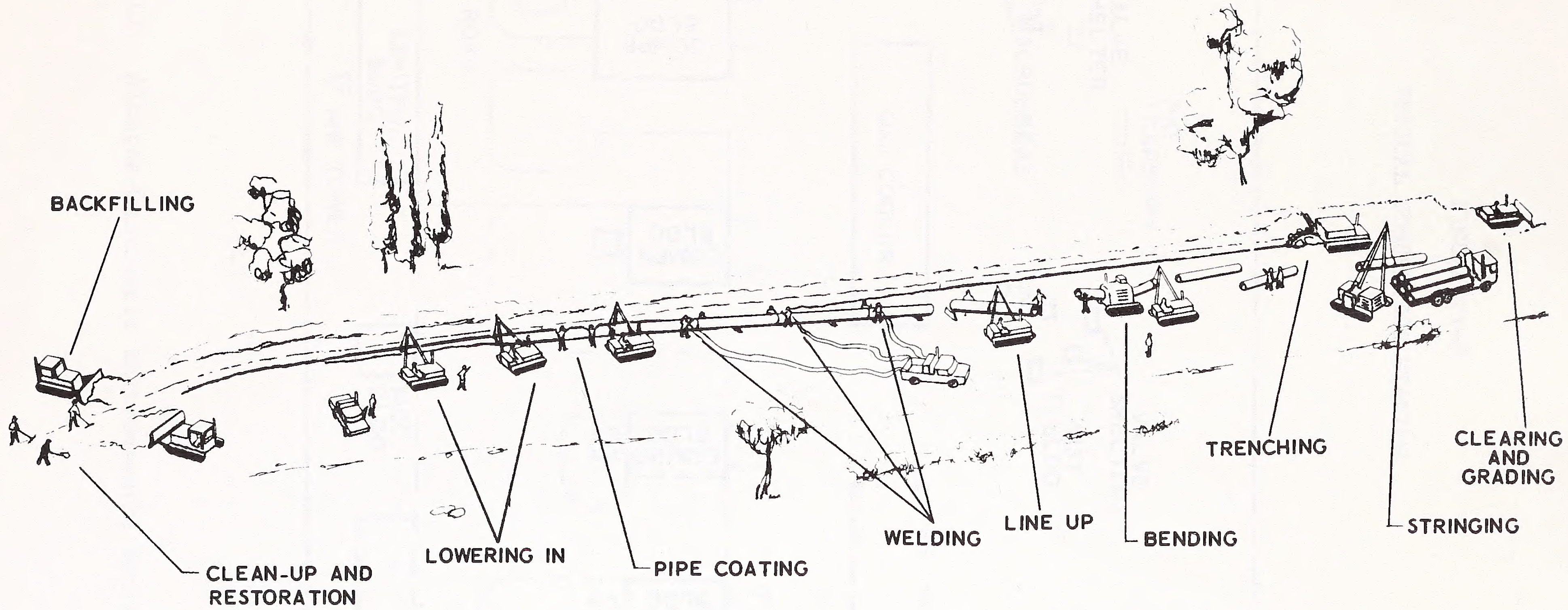
The most common carrier is steel pipe although concrete and plastic are sometimes used. The moving force over very short distances is frequently gravity alone, but for longer distances, pressure is applied to move the product through the pipe. A pipeline system includes pipe, pumps and compressors supplying the moving force, and all other facilities needed to protect, operate, and maintain the system. Figure VI-8 shows typical pipeline construction. It also indicates the amount of construction activity which determines the right-of-way width required. Figure VI-9 shows the layout of a compressor station of about 5 acres.

4. Anticipated Development

Pipelines are closely associated with fossil fuels and thus, with the entire complex of energy policy and investment procedures. Private industry and Federal policy decisions concerning the use mix between oil, gas, and coal along with prices of the commodities will indirectly impact pipeline construction. The actual location of deep water ports,

FIGURE VI-8

TYPICAL PIPELINE CONSTRUCTION SPREAD

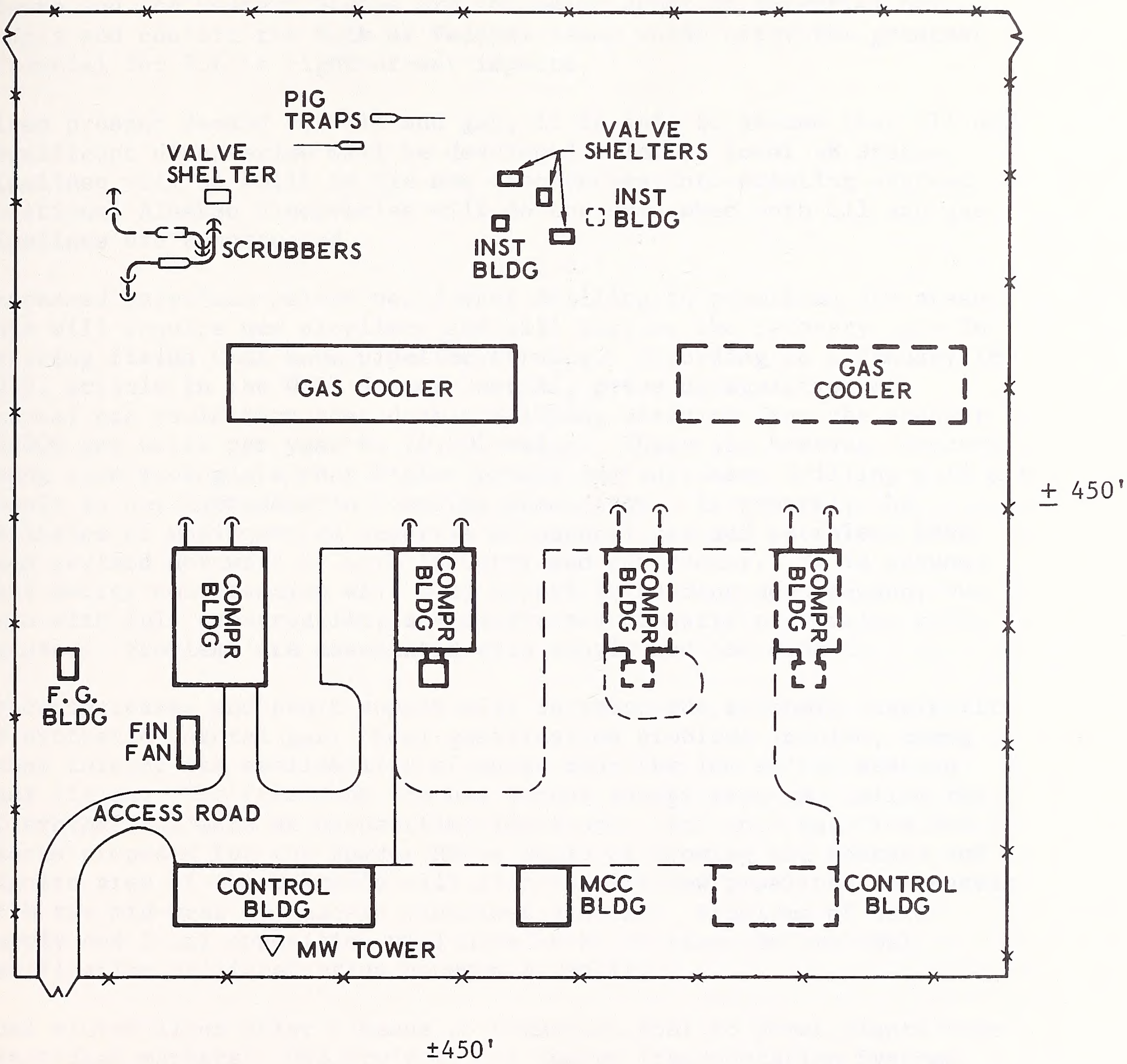


SCALE CONDENSED FOR ILLUSTRATIVE PURPOSES

SOURCE: The Aerospace Corporation, 1975

FIGURE VI-9

TYPICAL COMPRESSOR STATION



SOURCE: Alberta-California Environmental Report

liquid natural gas facilities, coal gasification plants, oil shale developments, and the rate of drilling oil and gas wells will directly affect the rate and location of pipeline construction.

The eastern two-thirds of the nation is presently well served by pipelines. There will continue to be additions and deletions to this system, but the impact on eastern Federal lands is expected to be negligible.

Alaska and the Western States are the major areas of potential new supply and contain the bulk of Federal lands which offer the greatest potential for future right-of-way impacts.

Given present demand for oil and gas, it is safe to assume that all new significant discoveries will be developed. In the lower 48 States, pipelines will be built to tie new discoveries into existing systems. Additional Alaskan discoveries will do the same when both oil and gas pipelines are constructed.

Increased petroleum prices would spur drilling in promising new areas. This will require new pipelines and will improve the recovery rate in existing fields that have pipeline service. According to a January 16, 1975, article in the Wall Street Journal, price deregulation of natural gas could more than double drilling activity from the present 33,000 gas wells per year to 70,000 wells. There is, however, concern among some geologists that higher prices and increased drilling will not result in net increases in domestic production. In general, the estimates of undiscovered reserves of natural gas and petroleum have been revised downward by both industry and government. It is assumed that energy conservation will play a part in holding down demand, but even with full conservation, any additional domestic production will be used. Problems are associated with supply and not demand.

Price increases and short supply will increase the economic feasibility of synthetic natural gas. Coal gasification problems involve, among other things, the availability of water near the low sulfur western coal fields. The President, in his recent energy program, called for 20 synthetic plants at unspecified locations. Any coal gasification plants proposed for the Powder River Basin of Wyoming and Montana and lignite area of the Dakota's will also require new pipelines to connect with the mid-west or eastern pipelines systems. Problems of water supply and local opposition will have to be overcome before coal gasification or liquefaction becomes a reality.

Coal slurry lines offer a means to transport coal to power plants near electrical markets. One project, the Energy Transportation Systems, Inc. pipeline, has acquired water rights and partial coal supply, but is experiencing political controversy and possible court action over water use. One of the basic shifts contemplated by Project Independence is substituting low sulfur coal for oil at electrical powerplants. This could lead to additional long distance coal slurry pipelines, provided water is available.

Pipeline needs for full oil shale development are still conjectural, but one firm, Colony Development Corporation, has filed a pipeline right-of-way application with BLM. An environmental impact statement for the Colony shale development is being prepared despite uncertainty about when the project may be implemented. Other companies are pursuing different technologies but proposed pipeline routings are unknown at this time.

In the past, there has been a close correlation between drilling activity, particularly exploration wells, and pipeline construction. Increased petroleum prices have caused a resurgence in drilling activity nationwide. Drilling activity has been noted particularly in the Green River and Powder River Basins of Wyoming, and the Permian Basin of southeast New Mexico and west Texas. Various basins along the Rocky Mountains are being explored for oil at record depths and for gas from sandstones previously considered too tight or impermeable for economic production. Additional pipelines linking the Rocky Mountain area to the eastern pipeline system can be expected if large quantities are produced.

The Alaskan North Slope oil discoveries have been widely publicized along with the Alaska pipeline. There are now several proposals associated with the delivery of natural gas. Also, there will be additional pipelines needed once Alaska oil and gas are delivered to the west coast. The Western Liquid Natural Gas terminal proposal with almost 300 miles of major gas pipelines and the Williams Brothers proposed crude oil line are examples.

While recognizing the complexities and uncertainties involved, a review of projects announced, rights-of-way applications filed with Federal Agencies, and information furnished by industry, have yielded some rough indications of expected pipeline activity on western Federal lands in the near future. These are shown in Table VI-7.

One of the most recent estimates for pipeline investments was made by the Federal Energy Administration of between $10.8 billion and $11.5 billion from 1974 to 1985. Considerably higher estimates have been made by industry sources. The main point is that investments in the billion-dollar-a-year range and higher are indicated.

No significant technological improvements in pipe size or installation techniques are expected by 1985 although incremental increases in operating pressures and improvements in pipe quality are expected to continue.

Probably the most significant impact of future pipeline construction will come from legislation and policy changes to meet the energy crisis. It is apparent that changes in price, depletion allowances, investment tax credits, clean air standards, oil and gas leasing, import levels, plant fuel changes, and Project Independence can increase or decrease pipeline construction and the need for rights-of-way.

TABLE VI-7

MAJOR PIPELINE PROJECTS AFFECTING WESTERN FEDERAL LANDS

Company (s)	Product	From	To	Size	Length Miles	Status
N. Border	Nat. Gas	Alaska	Penn.	48"	1,617	Proposed
PGT&PG&E	Nat. Gas	Alaska	Cal.	42"	917	Proposed
So. Cal. Gas	Nat. Gas	Alaska	So. Cal.	30"	200	Proposed
ITA (Arctic)	Nat. Gas	Alaska	Cal-Nev.	36"	877	Proposed
AK. Arctic	Nat. Gas	Alaska	AK.	48"	200	Proposed
El Paso - AK. (LNG Tanker)	Nat. Gas	Alaska	Cal.	42"	800	Proposed
Western LNG Terminal	Nat. Gas	Cal.	Ukn.	42"	286	Proposed
Williams Bros.	Alaska Crude	L.A. Cal.	Midland, Texas	Unk.	1,000 est.	Proposed
Trans. U.S.	Alaska Crude	Paci. N.W.	Midwest	Large	1,100	Under study
Dome	Liquids	So. Dak.	Mich.	1-10" 1-12"	1,122	Planned
Colony Oil Shale	Shale Oil	N.W. Colo.	Utah	16"	194	Planned
ETSI	Coal Slurry	N.East Wyom.	Pi. Bl. Ark.	38"	1,000	Planned
Houston Nat. Gas	Coal Slurry	N.W. Colo.	Texas Gu. Co.	18"	1,100	Under study
Pac, Power N.W. Pipeline	Coal Slurry	Wyo.	Oregon	Unk.	800	Under study
Ne. Power Co.	Coal Slurry	Utah	Las V. Ne.	20" 24"	180	Planned
	TOTAL				11,400 Mi. (rd.)	

NOTE: These projects have been announced in one form or another. This does not mean all will be built. Other projects may be substituted.

C. Communication Systems

1. Historic Development of the System

Historically, communication lines have paralleled railroads, highways, and electric transmission systems. This was due largely to the availability of existing rights-of-way and the low capacity and simplistic design of communication and electrical systems. Through the development of more complex, higher capacity communication systems, interference problems from other systems have been compounded. High voltage electric transmission lines with ever-increasing capacities further complicated the interference problems. Because of these developments, the trend changed to one of separating communication systems as much as possible from other systems which cause interference and adverse effects.

Open wire communication circuits carried on aboveground poles are generally not built any more, but a number are still in use, particularly in the Western States. Except for railroad communications, these circuits are being replaced by buried paired cables which are used for distribution systems up to about 250 miles in length. According to Bell System representatives, the objective is to have at least 50 percent of their hundreds of thousands of miles of aerial lines underground by mid-1975.

Coaxial cable was first used in 1946. The capacity of a pair of 3/8-inch coaxial cable lines has increased from 600 simultaneous telephone calls to 9,000.

Most long distance circuit growth since 1960 has been by microwave radio relay where demand for a large number of circuits warrants it. Buried coaxial cables have been constructed for trans-continental circuits where cable facilities are required and where the growth rate is high enough to warrant the cost of a higher capacity system. Buried waveguide systems, currently under development, hold much promise for the future.

2. Present System

There are about 20,000 miles of long distance circuits in the United States which are of three types: above ground, buried twisted pair, and buried coaxial cables.

There are no centralized records of the amount of communication lines located on Federal lands. The major existing and proposed communication lines are shown on Map #7, Communication Systems. For the purpose of this study, communication systems 100 miles or more in length are considered to be major, and therefore relevant. Microwave systems are excluded since they are point locations rather than connected lines, as envisioned within a corridor.

All transcontinental communication lines use 8-, 10-, 20-, or 22-tube coaxial cables with 1,800 circuits per pair of tubes for L-3 coaxial cables and 3,600 circuits per pair of tubes for L-4 coaxial cables.

Repeaters spaced at 4- and 2- mile intervals, respectively, are fed current over the inner coaxial conductor power loop up to a distance of about 80 miles. Two of these routes have been completed in recent years.

Regional routes include both open wire on poles and paired cables of various sizes. Open wire circuits are most susceptible to interference of various kinds. Paired cable systems have a maximum range of about 250 miles and require repeaters at intervals of 6,000 feet to 50 miles. There has been very little new construction of these types in recent years. Microwave radio has been used for essentially all long distance routes which in turn released line carriers for shorter circuit needs.

The average cost per mile for the construction of a new long distance communication line of L-5 coaxial cable is approximately $150,000.

3. Components of a Typical Communication System

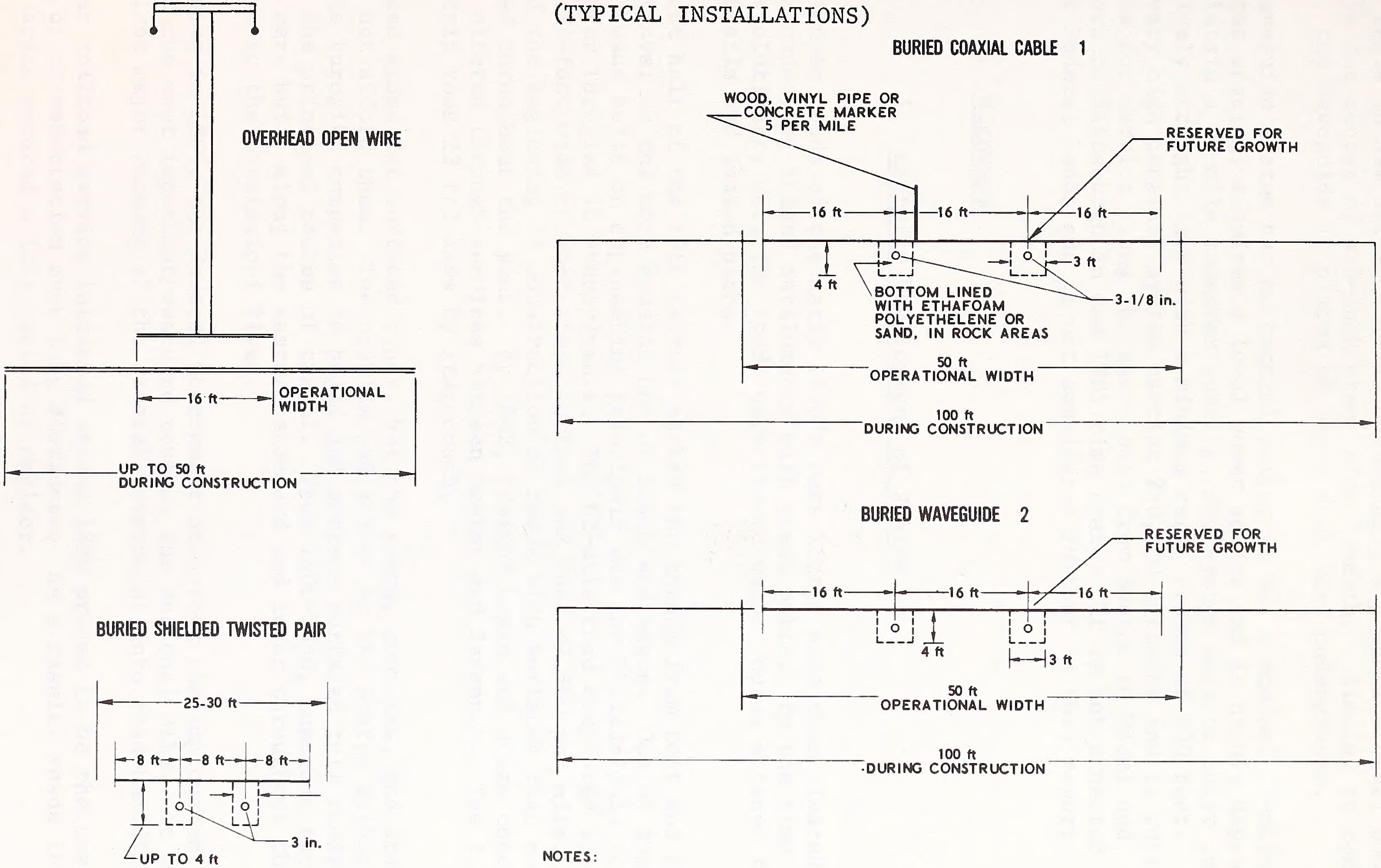
A typical communication system consists of a permanent right-of-way 16 to 50 feet in width, depending on system type, terrain, and future need as portrayed in Figure VI-10. In addition to the right-of-way, a construction easement of between 16 to 50 feet in width may be required if not obtained as part of the right-of-way. Other components include repeater and terminal facilities, electric power source, and an access road for operation, maintenance, and patrolling.

4. Anticipated Developments

Only a few major long distance communication lines are planned for construction across Federal lands within the next 10 years due to technological improvements which increase capacity of existing systems. Expanded capacity of existing microwave and coaxial cable systems is expected to provide for most of the circuit growth made through the 1980's. Two major L-5 coaxial cable lines are planned, one from St. Louis, Missouri, to Los Angeles, California, the other from San Francisco, to Los Angeles.

FIGURE VI-10

COMMUNICATIONS - SINGLE USE RIGHTS-OF-WAY
(TYPICAL INSTALLATIONS)


OVERHEAD OPEN WIRE
16 ft
OPERATIONAL WIDTH
UP TO 50 ft DURING CONSTRUCTION
BURIED SHIELDED TWISTED PAIR
25-30 ft
8 ft
8 ft
8 ft
UP TO 4 ft
3 in.
BURIED COAXIAL CABLE 1
WOOD, VINYL PIPE OR CONCRETE MARKER 5 PER MILE
RESERVED FOR FUTURE GROWTH
16 ft
16 ft
16 ft
4 ft
3 ft
BOTTOM LINED WITH ETHAFOAM POLYETHELENE OR SAND, IN ROCK AREAS
3-1/8 in.
50 ft OPERATIONAL WIDTH
100 ft DURING CONSTRUCTION
BURIED WAVEGUIDE 2
RESERVED FOR FUTURE GROWTH
16 ft
16 ft
16 ft
4 ft
3 ft
50 ft OPERATIONAL WIDTH
100 ft DURING CONSTRUCTION

NOTES:

1 REPEATER EVERY MILE-BURIED, MANHOLE 4x12x8 ft: ALTERNATE SYSTEM HAS REPEATER EVERY 17 mi. - 20x40x20 ft STRUCTURE

2 REPEATER EVERY 25 mi. - 20x40x20 ft STRUCTURE

3 INDUSTRY PRACTICE IS GENERALLY TO ACQUIRE ROW BASED ON CONSTRUCTION NEEDS

SOURCE: The Aerospace Corporation, 1975

A new type of facility, the WT-4 millimeter waveguide, is undergoing field tests in New Jersey. It is essentially a precision steel 60mm pipe in the center of a 5-inch steel pipe "sheath." Similar to coaxial cable, the waveguide is placed at least four feet underground.

The waveguide system has no control pairs; it has a nominal 25-mile repeater spacing; requires a local power source and is highly dependable. To maintain a 25-mile repeater spacing, the system must be built in a relatively straight line with a minimum curve radius of 200 feet. This very high capacity system carries 250,000 circuits and is currently planned for service along the east coast from Boston to Miami and New York to Pittsburgh in the 1985 time frame. It is not expected to impact Federal lands and is not considered further in this report.

D. Highways

1. Historic Development of System

The pioneer roads of the early 1600's were little more than cleared paths connecting inland settlements with ocean ports. By the time of the Revolutionary War, the roads were rutted wagon routes widened from pack trails and Indian paths.

The last half of the 18th century marked the change from foot and horseback travel to the more general use of coach and wagon. One of the first roads built on engineering principals was the Philadelphia to Lancaster Turnpike in Pennsylvania. The 62-mile road completed in 1796, had a 24-foot wide crushed stone surface and cost $7,500 per mile. It marked the beginning of construction of roads with surfaces that could be used throughout the year. By 1802, freight wagon and stage coach lines offered through-services between Boston and Savannah. The 1,200 mile trip took 22 1/2 days by stagecoach.

The need arose for surfaced roads, but the towns, counties, and States could not afford them. The problem was solved by the States authorizing private turnpike companies to build and operate surfaced toll roads along the principal routes of travel. From 1800-1840, numerous turnpikes were built along the eastern seaboard and later throughout the Midwest to the Mississippi River.

Beginning in 1806, the Federal Government undertook the improvement of one of the most important westward routes, the National Pike. It was the first major venture of the Federal Government into road building.

Regular railroad service initiated around 1830 proved to be the best means of transportation over long distances. As a result, roads in rural areas entered a long period of neglect.

By 1890, there were about two million miles of rural roads in the United States, but almost all were unsurfaced. With the advent of the gasoline automobile in 1893, there was an immediate need for better roads. As a result, by 1917, nearly every State provided financial aid to counties for road building. Gradually, the States entered into road work and assumed more and more responsibility.

In 1916, Congress passed the Federal-Aid Road Act which began the policy of providing Federal-aid money to States for road construction. An important improvement in Federal-aid policy was made in 1921 by a law which called upon the States to select a system of principal interstate and intercounty highways on which Federal-aid funds could be used.

There has been little expansion of total road mileage since 1916 when 80 percent of the present 3.8 million miles were in existence. While the total mileage has increased only moderately over the last 60 years, the overall quality of the roads has improved significantly. In the 1920's, major efforts were expended on hard surfacing roads for mud-bound rural areas. In the 1930's, the increase in the number and speed of vehicles dictated improvement of road design to eliminate steep hills, sharp curves, and blind spots.

The Federal-Aid Highway Act of 1944 authorized designation of the Interstate system of highways. The system, as originally authorized, was not to exceed 40,000 miles and was to connect as directly as practical the principal metropolitan areas, cities, and industrial centers to serve national defense needs and to connect at suitable border points with routes of continental importance in Canada and Mexico. Subsequent Federal-Aid Highway Acts of 1956 and 1968 added 1,000 miles and 1,500 miles respectively, to the authorized mileage. The present 42,500-mile system of controlled access freeways serves as the backbone of the American surface transportation network.

2. Present System

There are four Federal-aid highway systems: Interstate, primary, urban, and secondary. This study will only consider the Interstate system, officially called the National System of Interstate and Defense Highways, and the primary system.

Table VI-8 shows the mileages of the Federal-aid highway system in the Western States.

Table VI-9 shows the authorized mileage and cost of the Interstate system since its inception.

TABLE VI-8

MILEAGE OF FEDERAL-AID HIGHWAY SYSTEMS

WESTERN STATES	INTERSTATE	PRIMARY	SECONDARY & URBAN	TOTAL
Arizona	1,171	2,461	3,987	7,619
California	2,285	7,549	15,048	24,882
Colorado	979	3,637	4,302	8,918
Idaho	612	2,730	5,636	8,978
Montana	1,189	5,003	5,898	12,090
Nevada	535	1,760	3,781	6,176
New Mexico	999	3,030	5,981	10,010
Oregon	735	3,349	8,526	12,610
Utah	936	1,583	4,081	6,600
Washington	764	3,160	21,350	25,274
Wyoming	914	2,968	2,757	6,639
W. STATES TOTAL	11,119	37,230	81,347	129,696
U.S. TOTAL	42,497	228,959	647,493	918,949

SOURCE: Federal Highway Administration

TABLE VI-9

AUTHORIZED MILEAGE AND COST OF THE INTERSTATE SYSTEM

YEAR	MILEAGE AUTHORIZED	($ BILLION) FEDERAL SHARE (90%)	TOTAL COST
1944	40,000	1/	1/
1956	41,000	$22.5	$25.0
1961	42,500	37.0	41.0
1972	42,500	68.3	76.3
1974	42,500	72.0	80.0 2/

1/ No estimate readily available.
2/ Includes an estimate of $20 billion to complete the system.

SOURCE: Federal Highway Administration

As of June 30, 1974, 84.3 percent of the interstate system was open to traffic, 7.1 percent was under construction, 7.6 percent was in the planning stage, and 1.0 percent had not entered the planning stage. Of the 42,500 miles, 80 percent is in rural areas and 20 percent is in urban areas. Approximately 84 percent in each area is completed (Federal Highway Administration).

The primary highway system consists of a network of interconnected main roads of importance to regional, State, and interstate travel. There are 37,230 miles of primary highways in the Western States and 228,954 miles nationwide.

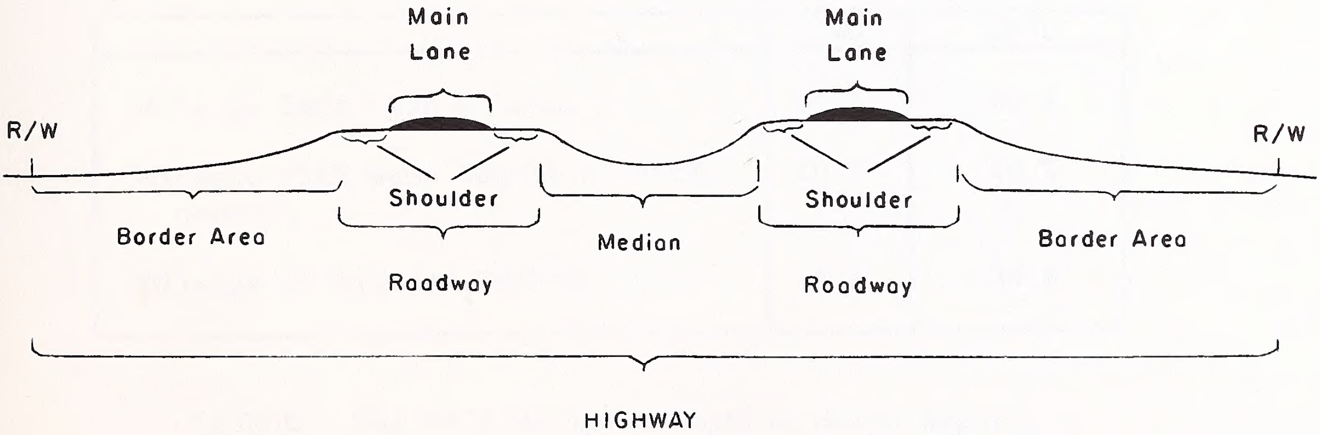
All Federal-aid highways combined total less than one-quarter of the national highway mileage, but they carry two-thirds of all traffic. The interstate system encompasses approximately 1 percent of the national highway mileage, but it carries more than 20 percent of all traffic.

3. Components of a Typical System

"Highway" is a general term denoting a public way for purposes of vehicular travel and includes the entire area within the right-of-way. The highway components are described in Figure VI-11.

FIGURE VI-11

CROSS SECTION OF A TYPICAL HIGHWAY



There is controlled access to the rights-of-way of all interstate highways. Within the right-of-way, there are at least four paved main lanes sufficient to carry two lanes of high speed, heavy volume traffic in each direction, a wide paved shoulder on each side of the main lanes and a median between the main lanes. Medians are generally wide grass-covered strips free from obstructions and separating opposing lanes of traffic. Interchanges are provided periodically for access to and from the highway. Also provided are rest areas and service areas at reasonable intervals.

Primary highways are mostly two or three lanes. Some have access control but most do not.

4. Anticipated Developments

It is anticipated that neither the mileage of the interstate system nor of the primary highway system will be enlarged significantly in the near future. For all practical purposes, the interstate system is complete since 99 percent of it is already constructed, under construction, designed, or the right-of-way is being acquired. Few major primary highways which would deviate significantly from the location of existing highways are being planned.

The 1972 National Highway Needs Report indicates that the rural Federal-aid primary systems are to be redefined to include other principal and minor arterial systems. The report indicates that if all "needs" were financed between 1970 and 1990, an extremely unlikely prospect, the following changes could be expected:

TABLE VI-10

PERCENT OF MILEAGES BY LANES, ACCESS CONTROL AND DIVIDED HIGHWAY

	1970	1990
Mileage less than 4 lanes	94 %	60 %
Mileage with some degree of access control	10 %	40 %
Mileage of divided highway	5 %	39 %

SOURCE: The 1972 National Highway Needs Report

E. Railroads

1. Historic Development of System

On July 1, 1862, President Lincoln signed the Pacific Railroad Act which authorized construction of a rail system to connect the Pacific coast with the Eastern United States. The first rails were laid July 10, 1865, at Omaha, Nebraska. Nearly four years later on May 10, 1869, the Union Pacific and Central Pacific Railroads joined their lines at Promontory Point, Utah.

Prior to 1875, special legislation provided right-of-way grants to each railraod applicant. The railroads were granted rights-of-way varying from approximately 100 to 400 feet in width, plus varying amounts of adjacent lands. As an example, the Pacific Railroad Act of July 1, 1862, granted a 400-foot right-of-way and every odd-numbered section of public land for a distance of ten miles on either side of the railroad. Mineral rights were excluded from this grant.

The General Railroad Right-of-Way Act of March 3, 1875, changed the previous policy of making individual railroad grants. It granted a 200-foot right-of-way through public lands but did not provide for land grants. It provided for obtaining construction materials from adjacent public lands and up to 20 acres every ten miles for station buildings and related facilities. The Act of May 14, 1898, authorized similar right-of-way grants to railroad companies in Alaska.

Railroad construction along the northeastern seaboard was nearly complete at the turn of the century, and by 1910, route mileage in the Midwest and Northeast approached its peak of approximately 78,000 miles. By about 1920, route mileage in the Nation reached its peak of over 250,000 miles. Since then it has gradually declined to approximately 234,500 miles and this trend appears to be continuing. At the same time, tonnage has continued to increase as the capacity of freight cars, engines, and tracks increased. Greater capacity has also resulted from improved signal systems, automated car handling, construction of additional main lines and passing tracks on existing railroad rights-of-way, and improved grades and curvature of existing tracks.

The Association of American Railroads was formed in 1934 to coordinate railway activities, including operations, maintenance, law, research, traffic, financing, accounting, taxation, and valuation.

The Interstate Commerce Commission regulates the interstate and foreign commerce aspects of the railroad industry, including schedules, rates, issuance of securities, and authority for construction and abandonment of rail lines.

2. Present System

According to the 1973 Rand McNally Railroad Atlas, there are currently 62 Class I railroad companies, with $5 million or more annual revenue, operating in the United States. They control the major portion of railroad lines, approximately 234,500 miles in the U.S., of which 41,000 miles are located in the Western States. (See Map #9.) Assuming the average railroad right-of-way width to be 200 feet, the area occupied by rights-of-way would be about 24 1/4 acres per mile or 5,685,000 acres in the United States. More than 994,000 acres of this would be in the Western States. This does not include additional area for station sites, yards, and other facilities. Statistics are not available for the amount of railroad rights-of-way crossing Federal lands.

In an effort to reorganize the railroads into an economically viable system, the Regional Rail Reorganization Act of 1973 (P.L. 93-236) established the U.S. Railway Association to plan and finance the restructuring of the ailing rail system. The Consolidated Rail Corporation was established to operate and modernize parts or all of the restructured system, and the Rail Services Planning Office of the ICC was established to hold public hearings on the Secretary of Transportation's recommendations and conclusions for rail services in the Midwest and Northeast Study Regions. These conclusions show that 25 percent of the railroad lines in the study region are potentially excess and that the remaining 75 percent could still carry 96 percent of the current traffic volume. However, the report does not fully assess the social, environmental, and related economic consequences of the proposed abandonment program. As of 1974, there were 320 rail abandonment applications pending before the Interstate Commerce Commission. Twenty-three are west of the 100th Meridian and involve about 345 miles of railroad lines.

The American Railroad Association indicates that, using 1974-75 cost data, it would cost from $500,000 to $700,000 per mile to construct a single mainline track, allowing for growth up to four tracks. It is recognized that this is an "average" range which could be higher or lower depending on a multitude of variables. Another significant factor is the rapid and unpredictable rate of increased costs for labor and materials; about 20 percent for the past year.

3. Components of a Typical System

A typical railroad right-of-way consists of much more than the obvious tracks, signals, and telegraph lines. Many of the uses commonly made of a mainline railroad right-of-way and related service areas are:

Single or multiple mainline tracks;

Siding or passing tracks;

Yarding tracks;

Hump yard for sorting, switching and classifying cars;

House tracks for loading and unloading areas;

Space to meet the needs of railroad shippers and receivers;

Signal structures;

Underground and overhead signal, power, and communication lines;

Bridges and drainage systems;

Fences along rights-of-way and yards;

Cut and fill sections;

Service roads;

Road crossings and approaches;

Highway grade separation structures;

Buildings and structures for housing, storage, repair; maintenence, and operation;

Water and fuel supply systems; and

Areas for disposing of snow and obtaining borrow material.

Other indirect components such as space for expansion, operational changes, and safety requirements are discussed later in the report.

4. Anticipated Expansion and Abandonments

The trend has been to reduce track mileage, not expand it. This trend probably will continue except for new tracks built to serve new mining operations such as the 113 mile line in Wyoming from Gillette to Douglas; a proposed line from Craig, Colorado, to Axial Basin, Meeker, and Rifle;

a proposed line from Craig, Colorado, to Baggs, Wyoming; and minor additions or improvements in New Mexico and California. Of the 113-mile line to Gillette, Wyoming, only 23 miles of the proposed route would be on Federal lands. All proposed rail additions will connect newly developed resource areas with existing rail lines.

Other future actions of the railroad system will be to improve grade and alignment of existing lines to increase speed and efficiency. Greater capacity needed by some lines may require additional parallel main lines and passing tracks. Industrial spur tracks will be needed to serve new or expanded industrial developments. Although such additions involve short distances, they create conflicts at road crossings, in land use and development planning, and in community continuity. Although it is not possible to accurately assess future right-of-way needs, it is essential that space be reserved for such expansion and modification requirements.

Some western railroads are seriously considering possible electrification of mainlines. Electrified railroads would not require additional right-of-way area, but substantial space could be needed for substations and power supply facilities.

Computerized freight car sorting procedures use automated switch yards. Signal and communication systems are reportedly undergoing technological changes which could have an effect on their compatability with other systems.

ICC regulations currently control about 14.5 percent of all barge freight, 36 percent of all truck freight, and 100 percent of all rail freight. The Environmental Defense Fund report, Proposal: Federal Acquisition of Railway Roadbed and Rights-of-Way in the Northeast and Midwest, August 12, 1974, suggested that Federal and State Governments abandon all subsidies on barge and truck traffic to permit railroads to compete on an equal basis. An alternative would be an equitable subsidy and regulation program for all transport modes. Another alternative would be for the Federal Government to acquire and maintain all mainline roadbeds, reconstructing where necessary. Rail abandonments represent a wide array of opportunities, such as use for recreation trails for hiking, bicycling, and snowmobiles, or for open space, commuting routes, and utility lines.

VII. RIGHT-OF-WAY REQUIREMENTS

A. Introduction

A right-of-way is a legal right for use, occupancy, or access across a land or water area for a specified purpose or purposes. The United States Code of Federal Regulations (CFR); Title 43, Public Lands, Interior, defines a right-of-way for administrative purposes as including a license, permit, or easement which conveys the legal right of passage over the specified Federal lands. Such documents convey to the holder control of the land for use of its system and designated related facilities. These documents do not convey any estate in the subject Federal land.

The holders of rights-of-way across Federal land may utilize the land only for that use authorized by the appropriate document. Any other use of the land would have to be approved by issuance of another permit, license, or easement or be considered unauthorized use. The same principles would apply for rights-of-way acquired across State lands. However, it should be pointed out that because of the permanence of highways and railroads, they essentially have control of all rights attached to these lands.

Rights-of-way across Federal lands are subject to revocation by the administering agency, under certain conditions, but such revocations have seldom been made.

Rights-of-way acquired over private lands generally differ from those across Federal lands. Highway and railroad rights-of-way are usually acquired in fee title, by negotiated purchase, and/or condemnation. Fee title conveys all property rights for the land, subject to valid outstanding rights. The utility companies usually acquire only the legal right of passage over private land, right to locate facilities, and the necessary control of the land for operation of their systems. However, in some cases they acquire fee title. Essentially, easements across private lands are acquired in perpetuity and are not subject to revocation.

B. Right-of-Way Criteria

1. Location

Selection of a route for any one of the five systems is complex and requires a great deal of study and planning. The planning process, by displaying the data and information acquired, the analysis of this data, the rationale used, and the full range of management implications, provides the basis for informed decisionmaking.

There are certain basic steps in route selection that are common to all systems. These are: system planning, study area selection, alternative route selection, and final route selection.

a. System Planning

For any given geographical area, it can normally be expected that all five systems will be present, though not necessarily in close proximity. Presently, there is little coordination or combined planning among all five systems. Planning is mostly on an individual system basis and varies within systems. Each organization within a system typically has a long range planning program. Such planning is necessary for each organization to meet future needs in given time frames. Normally, there is little overlap of boundaries of different organizations within a system because most have their own exclusive service area. This is particularly true of the electric transmission and communication systems.

Each system, and each organization within that system, must determine its future needs and how and when these needs will be met. Such planning must take place early, as it normally takes several years between the time a facility is proposed and the time it is in operation. Reasons for this lead time include: programing of financial resources, preparing engineering plans and specifications, considering environmental impacts, obtaining legal control of the land, and prefabricating portions of the facilities.

In the system planning process, there are certain determinants and parameters that must be identified for each system. The principal determinants that control route location include points of origin and destination, intermediate points of service, and essential connecting facilities, such as electrical switching stations. There is seldom any freedom of choice in providing line connections with these points, but there may be options as to how close the line should come to each point. The parameters vary according to the systems involved. Some of the more significant parameters for the various systems are voltage, current, number of circuits, pipe size, operating pressure, number of lanes, and system capacity.

Once the above information is known, several system plans are identified, followed by refinements toward more precise projects.

b. Study Area Selection

The project boundary includes an area between the points of origin and destination large enough to include all feasible alternative routes. The area is then studied to determine the specific characteristics in respect to the most practical routes.

c. Alternative Route Selection

This involves identification of alternative route locations within the study area. Various systems and organizations use different methodologies to determine route locations, ranging from professional judgment to sophisticated computer analysis.

Regardless of the methodology used, the selection of alternative route locations for any of the five systems generally considers at least the following factors:

Engineering Requirements
Topography
Bodies of Water
Geology
Soil Condition
Land Use and Ownership
Environmental
Existing and Proposed Systems
Reliability
Economics

Different systems have different requirements, even though they all consider the same factors. For example, grade is critical to railroads but is relatively insignificant to electric transmission lines.

(1) Engineering Requirements

All systems have different engineering standards. These are generally established by industry and are often endorsed by public regulatory agencies or incorporated into the agencies' regulations and policies.

Most transmission lines are constructed and maintained in accordance with the National Electric Safety Code (NESC). The electric companies also follow the standards of the National Electric Manufacturers Association (NEMA), and those of the Institute of Electrical and Electronics Engineers (IEEE). In addition, companies and agencies have their own standards. If there are conflicts between standards, the most stringent ones are followed. State and local codes and regulations vary.

Pipeline standards, practices, and guides have been established by industry groups such as the American Petroleum Institute and the American Gas Association, as well as by engineering societies such as the American Society of Mechanical Engineers and the National Association of Corrosion Engineers. Further constraints are imposed by the Office of Pipeline Safety in the Department of Transportation. Gas pipelines which come under the safety jurisdiction of the Natural Gas Pipeline Safety Act of 1968 (49 U.S.C. 1671 et seq.) are required to meet the regulations contained in 49 CFR Parts 191 and 192. Liquid pipelines subject to the Transportation of Explosives Act (18 U.S.C. 831 et seq.) and carrying hazardous materials such as crude oil, petroleum products, liquefied petroleum gases, and anhydrous ammonia would be required to comply with regulations contained in 49 CFR Part 195. There are also State and local codes and regulations.

Communication standards, practices, and guides have been established by industry, such as Bell Labs, and through such groups as the Edison Electric Institute, and the Institute of Electrical and Electronics Engineers (IEEE). In addition, the Federal Communication Commission and other Federal, State, and local government agencies impose criteria or codes.

The design standards for Federal-aid highway projects are set forth in the Federal Highway Administration's Federal-Aid Highway Program Manual, Volume 6, Chapter 2, Section 1, issued January 2, 1975. These standards are essentially those which have been adopted and published by the American Association of Highway and Transportation Officials.

Railroad engineering standards have been developed by individual railroad companies and the American Railway Engineering Association (AREA). However, the companies are not required to follow the standards established by the AREA except for the gauge of the track. No Federal Agencies issue regulations regarding railroad standards with the exception of the Federal Railroad Administration, which supervises the operation of the Alaska Railroad and issues regulations for track standards and signal systems.

(2) Topography

One of the most significant considerations in locating any system is topography. Flat or gently sloping areas are preferred; mountainous areas are avoided. As grade increases, so do costs for construction, operation, and maintenance. Mountainous areas require both horizontal and vertical curvatures for both railroads and highways. However, the direction of a highway across a flat area is often changed slightly to relieve the monotony of driving.

Topography determines the equipment to be used in construction. For example, in areas where severe environmental damage from normal construction methods is likely, helicopters may be used for transmission line construction. Even then, the high costs of helicopter-aided construction may preclude a route through a particular area. Slope and slope aspect are related to cost and potential for erosion.

Refer to Table IV-2 for a summary of the maximum allowable grade by system.

(3) Bodies of Water

The location and characteristics of bodies of water are often determinants in locating systems because of increased construction and maintenance costs, visual impacts, and decreased accessibility. The major effect occurs during construction. Once constructed, however, the systems, by themselves have little effect on water bodies except for the possibilities of oil spills from damaged pipelines.

Lakes, marshes, bogs, and swamps also are avoided whenever possible. Rivers are more difficult to avoid, and major river crossing sites receive special consideration because they often become control points for locating any system. In pipeline construction, underwater crossings are generally preferred to a suspension or supported crossing above the surface.

In exceptional situations, electric transmission lines have spanned bodies of water up to one mile in width. Likewise, railroads and highways have extended for several miles across water where the additional costs are warranted. When large bodies of water cannot be avoided by pipeline and communication lines, they are generally installed by special equipment in the bed of the water body. Occasionally they will be fastened to a structure, such as a highway bridge, spanning the water.

(4) Geology

Three important geologic considerations when locating systems are bedrock characteristics, geologic hazards, and mineral resources. Bedrock characteristics of concern to all systems include depth, hardness, strength, condition, and stability. These affect foundation stability, drainage, and the ease with which underground facilities can be installed. Naturally, areas with bedrock close to the surface are not preferred for any systems requiring extensive excavation. But, electric transmission line towers can be placed on exposed bedrock if necessary. Geologic hazards of landslides and bedrock subsidence must be considered. The presence of mineral or metallic ores and oil and natural gas fields influences the selection of alternate routes.

(5) Soil Condition

Soil condition, including soil type and rock, is a major factor in locating rights-of-way. Some of the more important soil characteristics that must be considered for all systems are erodability, electrochemical properties, texture, fertility, and bearing capacity.

Pipeline and communication systems construction costs are reduced in deep, well-drained, loamy soils; electric transmission, railroad, and highway systems construction costs are less on well-drained soils with a firm base.

The amount of moisture in the soil and its affect on soil stability is also important. Unstable soils adversely affect construction of all systems and require special engineering techniques. Excessive moisture also affects the freezing-thawing characteristics of soil and results in such undesirable characteristics as frost heaving.

(6) Land Use and Ownership

All systems attempt to avoid densely populated areas because of economic and safety reasons. The problems and costs associated with acquiring rights-of-way increase significantly in populated areas compared with those in rural areas. Standards of construction often change when facilities are near homes. For example, lower operating pressure or thicker pipe is required by the Office of Pipeline Safety for gaslines located near residences than for those in open country.

In many areas of the United States, right-of-way locations are constrained by land classification or designation. In some areas, these constraints are increasing. Land designations, such as wilderness areas, totally restrict these lands from right-of-way uses unless specifically approved by the President. Other examples of constraint areas with varying degrees of restriction are: Indian reservations, military reserves, State and national park systems, rare and endangered wildlife species habitat, and game ranges. In some cases, a combination of such constraints could prevent rights-of-way from crossing through large areas or regions. These constraints have a significant impact on the remaining lands available for right-of-way routes. Avoiding constraint areas may tend toward the development of natural land-use corridors on lands available for right-of-way use. In rural areas, most systems try to avoid land that is intensively farmed because of potential interference with cultivation and irrigation practices. Further, flood plains are generally avoided whenever possible. Open areas are preferred to timbered areas to reduce construction and maintenance costs, as well as to minimize aesthetic impacts.

Land ownership in relation to land use is important because public lands are generally managed for different purposes than private lands. Public lands managed for a special purpose, such as wildlife refuges, wilderness areas, and military installations, generally tend to be more difficult to obtain a right-of-way across than public lands managed for multiple-use purposes. Even on multiple-use lands, new laws, regulations, and environmental requirements have increased the procedural complexities of locating rights-of-way. There have been instances where companies have avoided all public lands rather than operate under additional institutional requirements such as wheeling stipulations.

(7) Environmental

In areas under multiple-use management, critical environmental areas requiring special management measures are usually found associated with rare and endangered wildlife species, archaeological areas, and historical sites. Such areas are avoided by all systems whenever possible. In some cases, systems seek to avoid public lands in order to avoid costly and time-delaying environmental impact statement requirements. However, many States either have enacted or are proposing legislation requiring environmental assessments similar to the National Environmental Policy Act requirements.

The approval process for construction of new facilities has become lengthened. Organized environmental interests working through both regulatory agencies and the courts have successfully caused the relocation of numerous facilities to areas where they would cause less environmental degradation. Preparing and assessing environmental reports have become complicated by the additional formal requirements which must be met in terms of the increased number of permits and authorizations. It is these permits and authorizations, however, which help to assure the environmental soundness of the location.

The Department of Transportation Act of 1966 states that it is national policy in highway construction to make special efforts to preserve public park and recreation lands, wildlife and waterfowl refuges, and historical sites of national, State, and local significance. Such lands are not used for highway purposes unless there is no feasible and prudent alternative and unless the highway project includes all possible measures to minimize harm to park lands, including compensation. New utility installations are not permitted in scenic strips and overlooks, rest areas, recreation areas, or within the rights-of-way of highways which are adjacent to any of these areas or which pass through public parks, recreation areas, wildlife and waterfowl refuges, and historic sites. Underground utility installations may be permitted where they will not impair the management or public values of such areas.

(8) Existing and Proposed Systems

Since not all systems are compatible in close proximity to each other, it may be necessary to locate a new facility a certain distance away to minimize interference. Some existing systems, such as twisted pair communication lines, were built with different standards than those used today and require costly mitigation to be made compatible with additional systems. The railroad industry recommends that highway crossings of main tracks be no closer than one-half mile apart. They also recommend that highways be located at least 1,000 feet from main tracks where there is a possibility of commercial or industrial development along the track. Electric transmission lines close to railroad, pipeline, and communication systems can cause interference problems; consequently, major communication routes are engineered to be at least one mile from paralleling electric transmission lines when possible. There are no uniform separation distances between pipelines and powerlines; each situation is assessed on its merits.

(9) Reliability

The location of a particular system plays a very important role in its ability to operate without significant interruptions of services. Reliability is often cited by utility companies as a locational requirement in order to minimize interruptions and provide acceptable service. For example, adequate space between paralleling electrical lines improves the reliability of the system by reducing the opportunity for an accident, sabotage, or natural disaster damaging both lines concurrently.

(10) Economics

The economics of each alternative route, particularly added costs related to length, are carefully scrutinized. Costs and benefits attributable to each route weigh heavily in the final route selection process.

d. Final Route Selection

Final route selection involves an evaluation and comparison of all feasible alternative routes and selection of the best overall location. This process usually includes public input.

From an engineering and economic viewpoint, other things being equal, the best location for any system is a straight line between two end points. This view assumes that it is most economical (which may be true) and disturbs the least amount of area (which may also be true). But, the straight line location is seldom used because it does not consider other relevant factors such as topography, accessibility, and environmental values. The straight line location does, however, provide the minimum possible length of the route which can then be a reference against which to compare alternative locations.

Because the requirements of a system seldom remain the same throughout the life of a project, it may be necessary to expand capacity or modify the system. Criteria for assessing alternative routes must include future expansion opportunities and the adequacy of the proposed location for future modifications.

The length of a particular alternative route could have an effect on cost and system performance. For example, in an electric transmission line, power losses are a function of distance, thus longer lines will result in greater power loss, which in turn will increase the cost of the electricity.

Normally, the best location is the most direct and least total cost route after fully assessing delivery, environmental, and social costs. This establishes a trade-off situation where the benefits of one objective must be made at the expense of another. After all alternative routes are evaluated, the final route is selected.

2. Width

The width of a right-of-way for any system is dependent on several factors, including construction, operation, maintenance, and technical requirements; projected system expansion needs; access; and legal control. Once a right-of-way is acquired, it is seldom reduced in width even though less area is normally required after the facility is constructed and in operation.

The width of a right-of-way affects the amount of land withdrawn from alternate usage, as well as the aesthetics, since the visual impact of a wide swath in the landscape is, other things being equal, greater than that of a narrow swath.

a. Construction, Operation, Maintenance, and Technical Requirements

Since each system has different right-of-way width requirements, each will be discussed individually.

(1) Electric Transmission Systems

The right-of-way width required for electric transmission lines is basically determined by mechanical and electrical clearances but may involve considerations for electromagnetic and electrostatic effects such as audible noise, induced voltage, and radio and television interference. Clearances are based on span length, line configuration as shown in Figure VI-4, ice and wind conditions, voltage level, and AC or DC operation.

A review of industry practices indicates a wide variation in the width of rights-of-way for various voltage levels. Typical industry widths for various voltages and circuits are shown in Table IV-1. Figure VII-1 shows typical electrical transmission installations.

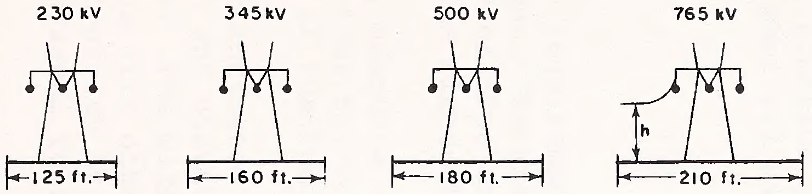
Conductor position is determined by:

Phase spacing and configuration - Minimum clearance between phases is based on NESC requirements and acceptable corona performance. The latter is particularly a factor at voltages of 500 KV and above. This distance can be measured horizontally, vertically, or at an angle, depending on tower configuration. Certain additional design criteria must also be met; for example, the design has to include adequate spacing to accommodate oscillations of conductors and ground wires in elliptical loops (conductor galloping).

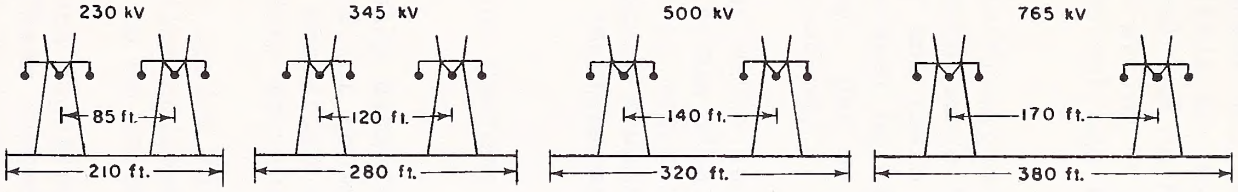
The tower configuration determines the position of conductors. The critical factor in any tower design is to provide adequate spacing between conductors. Some tower designs position the conductors in a flat configuration (horizontal pattern), some in a delta (triangular pattern), and others in a stacked pattern, one above the other. Due to variations in tower configuration, it is possible to construct a double circuit line (two circuits on the same tower) in about the same width as a single circuit line.

FIGURE VII-1

ELECTRICAL TRANSMISSION - SINGLE-USE RIGHT-OF-WAY (TYPICAL INSTALLATIONS)



TRANSMISSION LINE VERTICAL	APPROX h ft.			
CLEARANCE	230	345	500	750 kV
OVER PEDESTRIANS	26	31	38	49
OVER ROADS (vehicles)	30	34	41	52
OVER RAILROADS	40	45	50	62



TYPICAL DESIGN CONSIDERATIONS

- PREFER LINE-OF-SIGHT ROUTE
- STRADDLE EARTHQUAKE FAULTS (when possible)
- LIGHTNING GRND WIRE ABOVE CONDUCTORS
- LIGHTNING COUNTERPOISE UNDER TOWERS (lower cond soil)
- MEET WEATHER EXTREMES
- VEHICLE ACCESS (when possible)-PATROL AND MAINTENANCE
- MEET APPLICABLE FEDERAL/STATE REGULATIONS
- MEET NESC CLEARANCES
- DESIGN FOR ALLOWABLE INDUCED VOLTAGE, RI, TVI, AND AUDIBLE NOISE AT R/W EDGE

NOTE: ABOVE WIDTHS AND SEPARATIONS ARE FOR TYPICAL SINGLE CIRCUIT DESIGNS. HOWEVER, DOUBLE CIRCUIT REQUIREMENTS ARE APPROXIMATELY THE SAME.

SOURCE: The Aerospace Corporation, 1975

Conductor swing - The conductor will swing laterally under wind loads. The amount of horizontal displacement at mid-span is a factor of wind intensity and direction, conductor size and physical properties, conductor tension, span lengths, tower loading, and insulator configuration.

Clearances - The height of the conductor above the ground (the vertical clearance) is important because of safety considerations. The area between the outside conductor and the right-of-way edge is normally cleared of objects within arcing distance of a wind swung conductor (horizontal clearance) and maintained to prevent objects from falling or growing within arcing distance of the conductor. Ground clearance depends on the voltage level. It tends to be the same for both AC and DC lines.

Additional compensation for electromagnetic and electrostatic effects is necessary for equivalent performance from higher voltage lines. For example, audible noise, TV and radio interference, and induced voltages on ungrounded objects must be maintained at an acceptable level at the edge of the right-of-way. One method to obtain an acceptable level is by widening the right-of-way.

Theoretically, the right-of-way width could be variable with the maximum at mid-span and the minimum adjacent to the structures. This type of right-of-way would not be practical to acquire and administer. The standard practice is to obtain a uniform width right-of-way adequate to meet all mid-span requirements.

(2) Pipeline Systems

Construction requirements usually establish the width of rights-of-way for pipelines. The area needed for construction is directly related to the diameter of pipe and soil condition - as the diameter of the pipe increases, the right-of-way width increases.

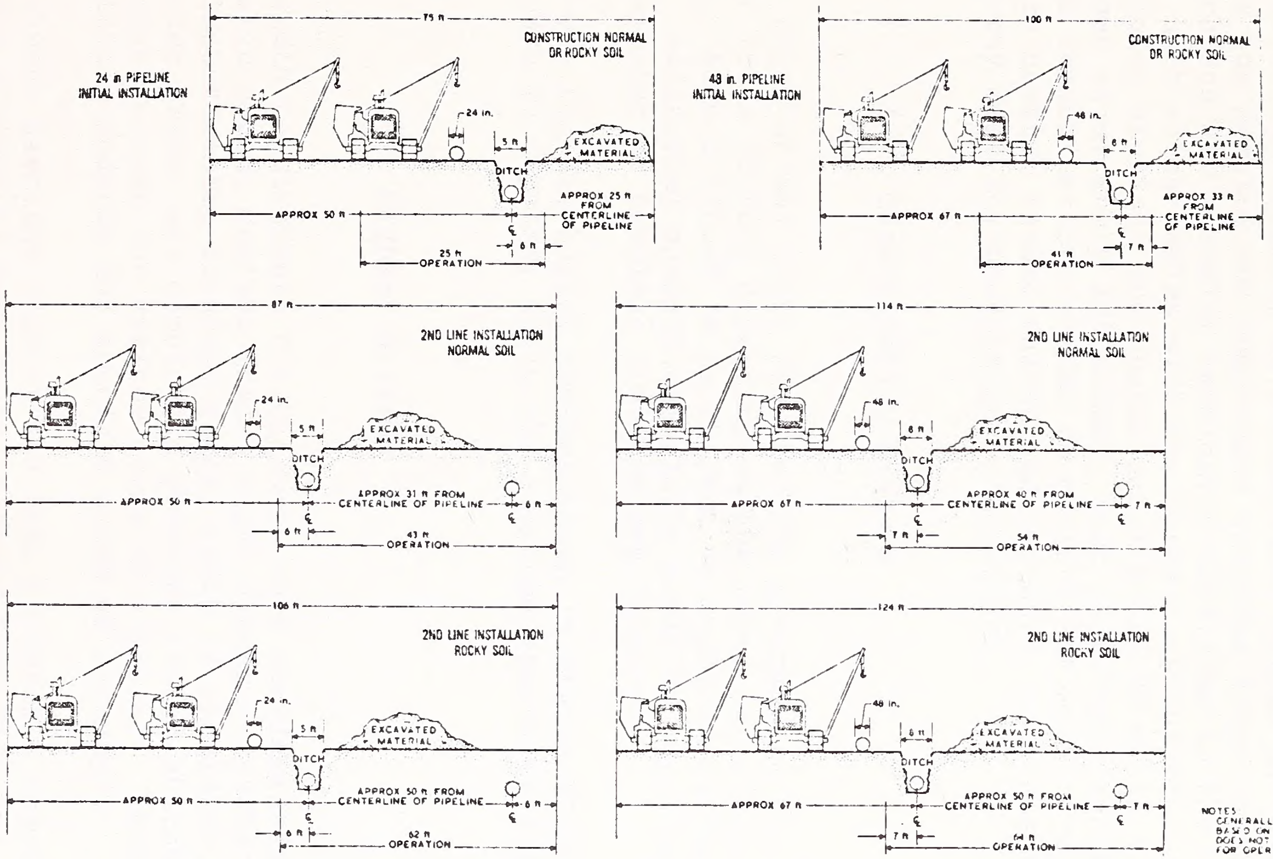
In addition, adequate space is needed for temporary storage of excavated material, access for construction equipment, and space for storage and preparation of the facilities to be installed.

Figure VII-2 indicates the width required for 24- and 48-inch pipe during construction and operation. These dimensions are for flat terrain with no obstacles. The width would be increased when slopes, rivers, or intersections with other systems occur. As a general rule, the width of the right-of-way at river crossings requires an area on each side of the river equal to the width of the river.

After construction, only about half of the right-of-way is actually needed for operation and routine maintenance. Seldom, however, is the right-of-way reduced because in the event that pipe replacement becomes necessary, the full width will again be required.

FIGURE VII-2

PIPELINES - SINGLE-USE RIGHT-OF-WAY
(TYPICAL INSTALLATIONS)



NOTES
GENERALLY, ROW WIDTH ACQUIRED IS BASED ON CONSTRUCTION NEEDS. DOES NOT REVERT TO WIDTH NEEDED FOR OPERATION

SOURCE: The Aerospace Corporation, 1975

Normally it is more economical to expand pipeline capacity through looping or paralleling an existing line than to build a new line in another right-of-way. Figure VII-2 depicts a parallel second-line installation with typical dimensions for pipeline separation and right-of-way width during construction and operation.

In both single and double line construction width, ancillary equipment such as block valves, bypass and blowdown assemblies, and cathodic protection devices can normally be accommodated within the operational widths. Sites for pumping and compresser stations range upward from five acres each and are normally considered additions to the right-of-way. The number of such sites varies with the terrain and pipeline product. Typically, pumping stations are spaced about every 30 miles and compressor stations about every 185 miles. Most pipelines require electrical and communication systems to operate automated pumping stations and to control remote valves and switches, consequently portions of a right-of-way must accommodate such facilities.

(3) Communication Systems

The permanent right-of-way width required for a communication system is normally about 16 to 50 feet depending on the type, terrain, and need for expansion. An additional 16 to 50 feet is required during construction. Additional operational widths would be required at those areas where repeater or terminal stations are located.

The rights-of-way for the buried systems shown in Figure VI-10 provide for future growth in capacity while the overhead open-wire illustration does not.

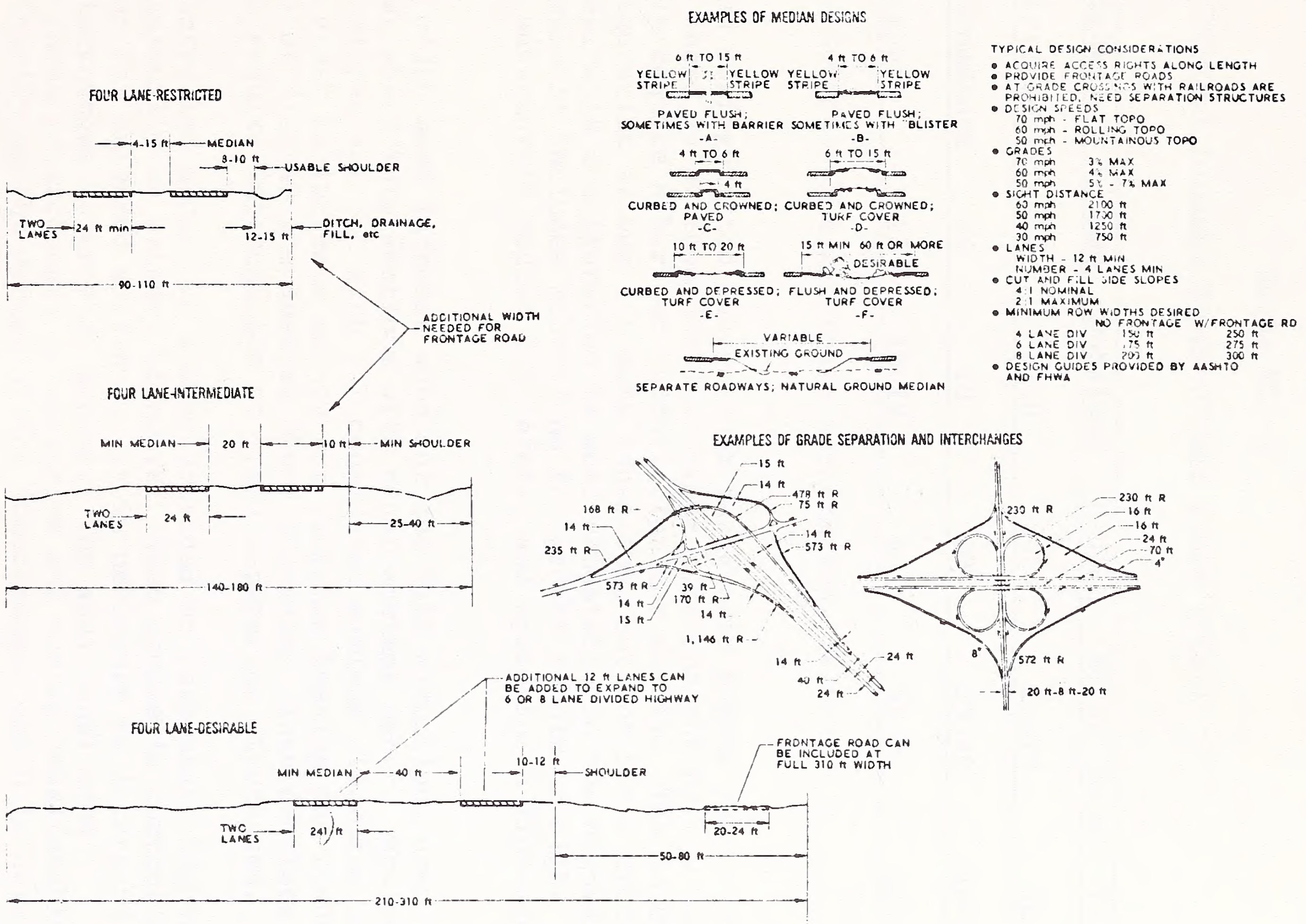
(4) Highway Systems

Right-of-way width requirements for highways vary considerably. Such factors as design speed, maximum grade, sight distance, number of lanes, cut and fill requirements, frontage roads, width of shoulders, and median and border areas, all combine to preclude the establishment of one standard right-of-way for various types of highways. There are, however, specific standards for specific types of highways.

Interstate highways have the highest and most inflexible standards. They must have a minimum of four lanes, each 12 feet wide and shoulders not less than 10 feet in width. Median widths range from a minimum of 4 feet to a desirable width of 60 feet. If conditions allow, the optimum right-of-way for interstate highways is 300 feet. If the right-of-way width is limited, the border area is reduced first, then the median, rather than the traffic lanes or shoulders.

FIGURE VII-3

HIGHWAYS - SINGLE USE-RIGHT-OF-WAY (TYPICAL INSTALLATIONS)



TYPICAL DESIGN CONSIDERATIONS

- ACQUIRE ACCESS RIGHTS ALONG LENGTH
- PROVIDE FRONTAGE ROADS
- AT GRADE CROSSINGS WITH RAILROADS ARE PROHIBITED, NEED SEPARATION STRUCTURES
- DESIGN SPEEDS
  - 70 mph - FLAT TOPO
  - 60 mph - ROLLING TOPO
  - 50 mph - MOUNTAINOUS TOPO
- GRADES
  - 70 mph 3% MAX
  - 60 mph 4% MAX
  - 50 mph 5% - 7% MAX
- SIGHT DISTANCE
  - 60 mph 2100 ft
  - 50 mph 1700 ft
  - 40 mph 1250 ft
  - 30 mph 750 ft
- LANES
  - WIDTH - 12 ft MIN
  - NUMBER - 4 LANES MIN
- CUT AND FILL SIDE SLOPES
  - 4:1 NOMINAL
  - 2:1 MAXIMUM
- MINIMUM ROW WIDTHS DESIRED

	NO FRONTAGE	W/FRONTAGE RD
4 LANE DIV	150 ft	250 ft
6 LANE DIV	175 ft	275 ft
8 LANE DIV	200 ft	300 ft

- DESIGN GUIDES PROVIDED BY AASHTO AND FHWA

SOURCE: The Aerospace Corporation, 1975

Generally, however, most primary highways are either two or four lanes and the rights-of-way normally range from 100 to 300 feet.

Table VII-1 is a summary of three typical examples of highway widths:

Table VII-1

TYPICAL HIGHWAY RIGHT-OF-WAY WIDTH (FEET)

Type of Highway	Lane	Shoulder	Median	Border Area	Total
4 Lane - Restricted	12	8-10	4-15	12-15	90-110
4 Lane - Intermediate	12	10	20	25-40	140-180
4 Lane - Desirable	12	10-12	60	50-80	210-310

SOURCE: The Aerospace Corporation, 1975

The restricted configuration has no room for growth beyond four lanes. In addition, there is no room for a frontage road and the narrow median would probably require a barrier installation for safety. The intermediate configuration allows for some expansion, but not for a frontage road. The desirable configuration is most acceptable to the highway industry because it includes provisions for growth to six or eight lanes, has a substantial median for safety, and space for a frontage road.

Right-of-way width must increase when cut and fill situations are encountered or where intersections with other systems occur. Nominal cut and fill slopes are 4:1 with 2:1 considered maximum allowable except in rock. In order to increase safety for vehicles leaving the roadway, slopes of 6:1 or flatter are desired where possible. Intersections with other systems require interchanges or grade separation structures.

Limited or controlled access is always provided on interstate highways, but only occasionally on primary highways. When access is controlled on any highway for extended distances, it is necessary to incorporate a series of interchanges to provide access. The additional area required for these interchanges is extensive and varies considerably, depending primarily on the design of the interchange, which is determined by the predicted volume of traffic. In some areas, limited or controlled access highways restrict local traffic patterns to such a degree that frontage roads are necessary, increasing the overall right-of-way width.

(5) Railroad Systems

Railroad right-of-way width depends on the area required for cut and fill; communication, signal, and power facilities; service roads; drainage; and the road bed. Figure VII-4 depicts a typical right-of-way cross section with a 45-foot crushed rock base (ballast) for two tracks. Allowing 55 feet for drainage facilities, signaling, communications, and an access road for maintenance and repair activity, it appears that a right-of-way width of 100 feet is adequate for reasonably level terrain. Additional width could be necessary for grade separations, cut and fill sections, drainage requirements, and safety.

The issues relevant to varying width dimensions in a single right-of-way are complex; however, excluding safety and other factors, "technical" restrictions vary with the situation. In fact, if at a particular cross section there were only a single mainline track and a single lane access road, the "technical" right-of-way requirements might be as narrow as 60-70 feet. However, the Railroad Right-of-Way Act of 1875 provides for a 200 foot right-of-way.

b. Access

Access requirements for all systems are generally different during construction than during operation. During construction, there must be provisions for moving men and equipment from potential supply centers. While this requirement does not generally impose significant constraints on line location, it does involve engineering and environmental considerations. Accordingly, the longer the distance between the supply point and the facility, the greater the costs, delays, and surface disturbance.

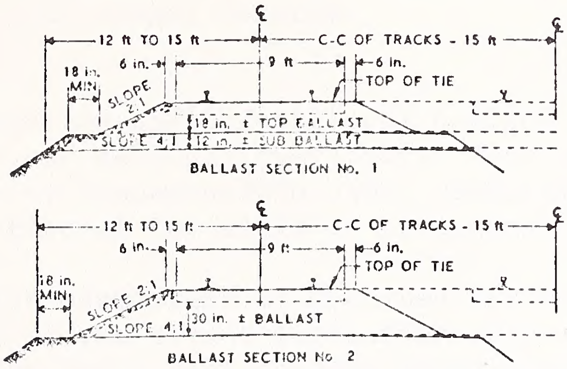
Once the system is in operation, it is inspected periodically from the ground or from the air to detect damage or deterioration requiring repair. Unless repairs are major, only a small portion of the right-of-way is used for maintenance purposes.

While all systems provide vehicular access, the quality of the access road varies considerably. On steep grades, it is often necessary to locate the access road outside the normal right-of-way, consequently, the facility right-of-way is expanded or a separate road right-of-way is acquired.

The highway system uses the highway itself for maintenance purposes; the railroad system uses a combination of the track and paralleling

FIGURE VII-4

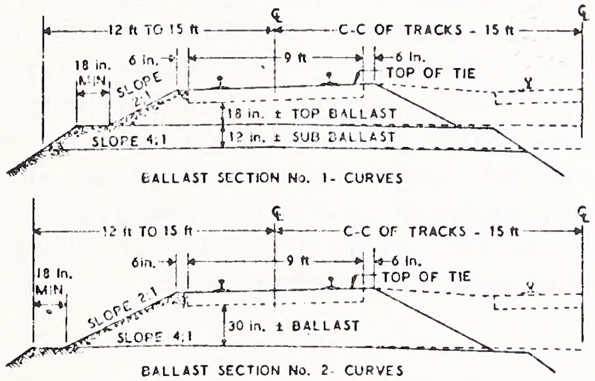
RAILROADS - SINGLE-USE RIGHT-OF-WAY
(TYPICAL INSTALLATIONS)



AREA BALLAST SECTIONS, SINGLE AND MULTIPLE TRACK, TANGENT

NOTE: DISTANCE BETWEEN RAILS 4 ft 8-1/2 in. (measured 5/8 in. below top of rails on two inside edges of rail)

NOTES:
DEPTH OF BALLAST SECTION TO BE USED WILL DEPEND ON CONDITIONS PECULIAR TO EACH RAILROAD OR LOCATION
SECTIONS APPLY TO ALL TYPES OF BALLAST
SECTIONS FOR USE WITH JOINTED OR CONTINUOUS RAIL
TOP OF BALLAST DETERMINED BY THE USE OF VARIOUS MECHANIZED BALLAST DISTRIBUTING OPERATIONS



AREA BALLAST SECTIONS, SINGLE AND MULTIPLE TRACK, CURVES

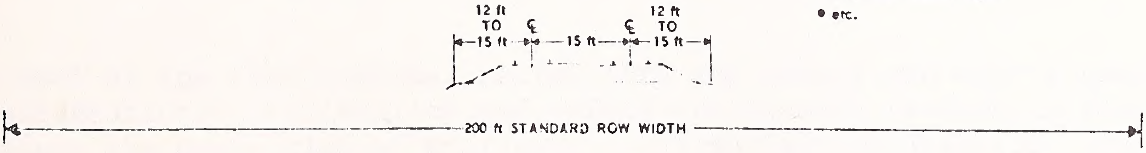
NOTES:
DEPTH OF BALLAST SECTION TO BE USED WILL DEPEND ON CONDITIONS PECULIAR TO EACH RAILROAD OR LOCATION
SECTIONS APPLY TO ALL TYPES OF BALLAST
SECTIONS FOR USE WITH JOINTED OR CONTINUOUS RAIL
TOP OF BALLAST DETERMINED BY THE USE OF VARIOUS MECHANIZED BALLAST DISTRIBUTING OPERATIONS

TYPICAL DESIGN CONSIDERATIONS

- CRITICAL FACTORS - TERRAIN, DRAINAGE
- TRAIN RESISTANCE 6 lb/ton
- GRADE - MAINLINE
  1% MAX DESIRED,
  2.2% RARE
- CURVE RESISTANCE
  0.8/ton/° CURVE OR
  0.04% GRADE/° CURVE
  COMPENSATION - REDUCE GRADE
  0.04%/° CURVE
- FED RAILWAY ROW ACT 1875 SET ROW 200 ft
- RURAL LOCALES 1000 ft SEPARATION REQ'D RR AND HIGHWAYS FOR MANUFACTURING OR INDUSTRIAL PLANTS
- SAFETY TO HIGHWAYS FROM TRAIN DERAILMENT

OTHER PHYSICAL USES (beyond track) ALONG RIGHT OF WAY INCLUDE, BUT NOT LIMITED TO, THE FOLLOWING EXAMPLES:

- MULTIPLE PARALLEL SIDING OR PASSING TRACKS
- MULTIPLE PARALLEL HOUSE TRACKS TO PLACE STANDING TRAINS, etc
- YARD TRACKS AND INSTALLATIONS FOR SORTING, SWITCHING AND CLASSIFYING CARS
- EMBANKMENTS OF CUTS AND FILLS
- OVERHEAD WIRE FOR POWER, SIGNAL OR COMMUNICATION SYSTEMS - ALSO FOR UNDERGROUND SYSTEMS
- GRADE SEPARATION STRUCTURES
- DRAINAGE SYSTEMS
- AREAS FOR STORAGE OF EQUIPMENT AND MATERIALS FOR REPAIR OR MAINTENANCE
- WATER AND FUEL SUPPLY SYSTEMS
- STATION STRUCTURES
- etc.



SOURCE: The Aerospace Corporation, 1975

service roads; other systems require a special year-round access road to each aboveground facility, such as towers and pumping stations. Access to the remaining facilities, such as conductors, buried cables, and pipelines is generally by four-wheel drive vehicles along the right-of-way.

c. Legal Control

Each system requires sufficient legal control over the rights-of-way to insure safe and reliable operation. This control includes the right to restrict noncompatible uses. Control is generally secured by the acquisition of fee title or easements.

Fee title or the equivalent is acquired for railroad and highway rights-of-way because of the strict limitations placed on other possible uses of the land involved. Both systems require absolute control over all activities within their respective rights-of-way, including access. Access to rights-of-way for railroads, interstate highways, and some primary highways is limited to insure safe operation of the facilities; in most instances, an additional right-of-way is acquired for this purpose.

Easements are normally acquired for electrical, pipeline, and communication system rights-of-way. Partial title is sufficient in most cases because the three systems do not actually occupy the entire right-of-way after construction and can permit several compatible land uses. Previous land uses such as farming or grazing which are compatible with the systems are allowed to continue subject to the right to operate and maintain the facilities. However, occupancy of the right-of-way is precluded. Any construction activity on or near the right-of-way is closely monitored to avoid potential interference with the operation of the system.

All systems consider the legal liability for the safe operation of their systems extremely important. This concern is reflected in all rights-of-way by the addition of extra width as a safety margin; most noticeably the highway and railroad systems.

3. Reliability and Safety Considerations

In each of the five systems, reliability and safety are significant considerations. Reliability and safety are closely related in that both concern the prevention of accidents. Reliability is primarily concerned with the ability of a system to provide uninterrupted service or products; safety relates to the potential that may exist for property damage or personal injury.

Reliability is influenced by many natural phenomena, including earthquakes, landslides, lightning, and flooding. Avoiding the consequence of these dangers, as well as avoiding areas prone to their causes, increases the cost of constructing and operating the systems.

When speaking of "required reliabilities," the two groups under discussion - transportation and utilities - have distinct differences - time, and the impact of disruption of service. The transportation group, including pipelines, normally requires considerable time to transport material or people between points, and some disruption of service may be costly or inconvenient, but not necessarily catastrophic. For example:

- A leak in a gas or oil pipeline would require detection and then repair; however, even significant losses could be backed up on an interim basis by stored reserves at the destination. Without reserves, gas transmission line failures cause additional expense and inconvenience through relighting pilot lights at each point of consumption;

- Flooding of a highway would cause delays or rerouting of traffic; and

- Derailment of a train would interrupt service requiring cleanup and repair with various degrees of delay.

Conversely, the utilities group, under normal conditions, requires essentially no time for transport of its product and, on primary lines, even small disruptions might result in considerable consequences to some, or many of its users. For example:

- Loss of a primary powerline can result in significant problems and costs for industrial users and the public beyond simple delay; and

- Loss of a primary communications line could result in significant problems to various users, negating, in the extreme, required emergency actions.

The above examples are indicative of possible consequences associated with disruption of service (reliability) for each of the five systems.

The achieved reliability for any of the five systems is based on soundness of the system design, safety factors for variations in the load, ability to handle abnormal occurrences, applied preventative maintenance, and adherence to sound operational or control procedures. Many of these same elements must be considered for each system when determining what must be done to protect people in or near the right-of-way from injury or death.

Minimizing the potential for accidental damage, injury, or breakdowns in the systems is essential and is a primary factor in routing each of the systems to avoid hazardous situations, particularly in densely populated areas.

a. Electrical Transmission

In providing the reliability essential to electrical transmission, line routing must ensure:

- System redundancy, alternate connected paths for providing power to users; and
- Protection necessary to minimize the likelihood and consequence of line failure relative to the right-of-way location and importance of the line.

Experience with the northeast blackout in 1965 indicates the effects of failures within a system resulting in cascading, widespread outages that disrupted a major portion of the bulk power supply network. The present reliability goal is based upon total system(s) availability within reasonable limits at the consuming end, considering all of the electrical generating sources available to that consuming area.

A National Electric Reliability Council with nine regional reliability councils has been established to design criteria to avoid cascading outages. The criteria require that critical system conditions, such as multiple circuits on a common right-of-way, be tested through simulation during the system design to examine an outage, consider possible effects, and devise corrections to keep the effect from becoming widespread.

Outage of a line to a single industrial plant would rarely cause widespread disruptions, but outage of certain high voltage lines could disrupt service to a major urban center. The latter effect would be of major concern and the most reliable configurations should be employed.

History has shown that single circuit rights-of-way exhibit more reliability than multiple circuits on the same right-of-way, because single occurrences, such as lightning and low-flying aircraft, could remove both circuits. Specific data on the degree of reduced reliability is not available. Power Technologies, Inc., in 1973, conducted a survey which "produced ample evidence that close proximity of circuits does degrade reliability." Presently, a task force of the Power System Engineering Committee of the Institute of Electrical and Electronic Engineers is conducting a study on multiple circuit outages for lines of 230 KV and above.

The general goal for reliability by the electrical industry is to implement systems wherein interruptions to service are confined to limited areas with restoration possible within a short time - avoiding cascading, widespread outages.

Safety for electrical transmission is achieved through system design, appropriate construction techniques, requisite maintenance, and sound operating practices. Significant to safety are conductor spacing, span length, conductor height above ground, and distance to edge of right-of-way. Right-of-way dimensions and vertical clearance of conductors are established to maintain induced electrostatic or electromagnetic voltage and current to levels which avoid hazards to people or animals in or near the right-of-way.

b. Pipelines

Basic pipeline reliability is established by the initial system design which is developed to accommodate a certain range of capacities for injecting, transporting, and storing oil or gas. Reliability is further maintained through appropriate material selection, construction criteria, and adequate tests and inspection.
Standards are established and enforced by the Office of Pipeline Safety under authorities cited elsewhere in this report. From statistics compiled by OPS, pipeline damages are primarily caused by corrosion or physical damage to the pipeline from other sources.

Protection from other sources during construction and operation is usually achieved through sufficient right-of-way width to provide separation from external influences. In addition, appropriate markings or identifications are used to help prevent accidental damage to a buried line. One function of regularly scheduled aerial inspection is to watch for encroaching land uses, construction, or other activities that may endanger the pipeline. Periodic, usually annual, inspections are made of the cathodic protection devices which prevent pipeline corrosion.

c. Communications

Similar to electrical transmission, the required reliability by the communication system is dependent on the route length, the needs of the users, and the capacity of alternate lines to absorb the traffic from disrupted lines. Loss of a single communication line to a community could result in total isolation and may endanger lives; while loss of a single line to an area with multiple systems could result in temporary disruption of service, but not community isolation. However, exceeding the capacities of alternate lines may temporarily block the entire system.

According to the communication work group report, industry's goal for service reliability is one loss of service per thousand miles per year. For the 20,000 miles of long distance network, this is roughly 20 outages per year.

Safety in a communications right-of-way is achieved through right-of-way width, appropriate construction and operating practices, and an adequate maintenance and repair program. The primary safety problems identified by the communication work group report are related to vehicular accidents and electrical contact to maintenance personnel. These occur most often in joint-use situations or intersections with other systems. Placement of communication lines in long parallels with powerlines are avoided when possible.

d. Highways

For highways, reliability of service is achieved through appropriate system design including geometric standards for horizontal and vertical curves, widths, grades, sight distance, clearance, and shoulders. Reliability is maintained through strict construction and maintenance standards, patrolling, testing, and inspecting.

Design of items which contribute directly to safety includes access control, number and width of lanes, median width, lateral separation from fixed objects, shoulder width, alignment, grade, traffic control devices, and side slopes of cuts and fills.

During operation, the above factors aid in maintaining desired safety levels; however, a significant factor affecting highway safety, which is controlled to various degrees, is the speed of the vehicles which use it.

The major contributors to improved safety are controlled access, adequate lane width, divided highways with substantial medians or suitable barriers, and adequate speed restrictions.

e. Railroads

Reliability is achieved through the basic design of all components, and is maintained through material selection, safety factors, construction technique, testing, and inspections. Design criteria on curves, grades, ballast, drainage, rolling stock, and communications all contribute to achieved service reliability.

In operation, safety is achieved through control of those factors which cause accidents, primarily through preventive maintenance and traffic control techniques. Electrical interference to the railroad signal system causing malfunction or failure must be prevented to assure safe and reliable service. Periodic inspections are required of trestles, culverts, rails, ties, roadbed, rolling stock, fences, etc., to assess their condition and to repair or replace as needed. Signal systems are used to safely control traffic. Adequate right-of-way widths provide space to contain most accidental occurrences such as items falling from trains and derailment.

For all five systems discussed above, there are varying criteria for reliability and safety. The achieved reliability or safety for any system is difficult to define and relate to the whole. Available statistics are not directly applicable to the undeveloped rural environment which this report is addressing.

4. National Security

This discussion examines the national security implications of overt and covert actions by potential enemies to systems across Federal lands.

a. Overt Threat

The basic concern is whether or not systems in close proximity to each other, such as joint use of rights-of-way, would become preferential targets and thereby adversely effect our national security. This discussion postulates that an enemy would attack utility and transportation facilities serving major population and national security centers for the purpose of isolating the people and thereby destroying their will to resist aggression or possibly to coerce the nation into accepting unfavorable international agreements. The basis for considering such a threat is found in recent planning studies sponsored by the Department of Defense, one of which considers transportation and utility systems to be attractive targets in limited aggression situations.

Electric transmission lines are the most vulnerable from nuclear attack, followed by railroads, highways, and pipelines, with communication lines being the least vulnerable.

Systems in close proximity are more vulnerable than widely separated systems. Consequently, it is possible to increase the security of systems significantly by widening their spacing and putting the least vulnerable systems at the outer edges.

b. Covert Threat

The closer systems are together, the greater the chances that damage to one system may damage an adjacent system - "a bonus kill." For example, overturning transmission towers may block adjacent highways or railroads; blowing up a gas pipeline may generate enough debris to temporarily block adjacent highways and railroads. In general, there is greater potential for a "bonus kill" from covert actions when systems are in close proximity. On the other hand, it is easier to physically secure and protect systems in close proximity than when they are widely separated.

For both overt and covert threats, extensive data gathering, analysis, and modeling would be required to determine the vulnerability and strategic importance of existing and future systems.

C. Interrelationship Between Systems

There has been a growing interest for greater sharing of rights-of-way. This may be attributed to continuing right-of-way needs for transportation and utilities, escalating land costs, increasing property taxes, increasing operation and maintenance costs, and increasing public interest in land use.

There are numerous examples of two or more systems located in joint-use rights-of-way. In many instances, particularly in urban environs, all five systems are located side by side - forced together by binding constraints such as lack of space or extremely high land values. Such joint-use rights-of-way generally exist for short distances only. Joint use is also found in rural areas such as a pass in a mountain range or a river valley where natural features force two or more systems to share the same or closely spaced parallel rights-of-way.

Because each system has its own operational requirements and each requires a certain amount of land, system conflicts and incompatibilities must be identified and mitigated to the extent practical and feasible from economic, social, and environmental standpoints before sharing rights-of-way. Conflicts can generally be related to one or more of the following:

1. Origin and destination differences;

2. Safety for people, equipment, and the system;

3. Reliability of the system;

4. Cost increases and distribution;

5. Adverse electrical effects;
6. Corrosion protection;
7. Ease of access and maintenance;
8. Opportunity for growth and expansion;
9. Flexibility in route selection;
10. Restrictions of crossing other rights-of-way;
11. Effective coordination;
12. Legal, administrative, and political issues; and
13. Aesthetic design compatibility.

Specific data on current and past joint-use experience should be useful in formulating judgments relative to problems that might occur in future instances of rights-of-way sharing. However, a review of available data indicates significant disparity among like instances of parallelism.

For example, some 10 miles of parallelism between a coaxial communication cable and a 345 KV powerline with 3,500- to 6,200-foot separation used coaxial cable installed in steel pipe for shielding, with no known service problems resulting. A similar example in another area with 10 miles of coaxial cable and a 345 KV transmission line with 500- to 5,000-foot separation, but no steel pipe shielding, also had no service problems.

Assuming sound judgment was exercised in both cases there must be obvious differences between the two cases, resulting in mitigation (steel pipe shielding) in the former case and not the latter. Specifics of the particular designs, quality of construction, preventive maintenance procedures, characteristics of the soil, and criticalness of communications are factors that in total, or in part, caused the disparity between the apparently similar cases.

Similar incongruities in the data are apparent for other system combinations or combinations of like systems. Some companies indicate pipelines must be hundreds of feet from electric transmission lines, others state 10 feet from the base of the tower, while others have located directly under an electrical transmission facility. For two pipelines in the same right-of-way, many companies prefer a separation of 25 to 30 feet, centerline to centerline; others indicate up to several hundred feet is desired, and many parallel systems have been installed with 3- to 10-foot separation for short distances.

The differences in joint-use experience are not presented to demonstrate conflicting data, but rather that experience cannot be used to arrive at any one general conclusion or guide. Before such data can be applied to future situations, specifics of these experiences need to be evaluated. The specific variances relate to a variety of factors such as specific design, construction quality, reliability, safety, preventive maintenance procedures, operational requirements, local environment, soil characteristics, local codes, historic practice, and legal factors, to name just a few.

Acknowledging such disparities between joint-use rights-of-way, there are identifiable compatibility and incompatibility factors.

1. Compatibility

One example of compatibility is identified in a current study by the Detroit Edison Company and eight participating utility companies to determine the feasibility and applicability of a joint-use utility corridor in the urban Detroit area. The study area is 18 miles square with the utilities located in a grid pattern. This is a highly developed urban area and not directly comparable to Federal lands. However, it does show that technically all five systems can co-exist in a shared right-of-way for at least a short distance. It is recognized that significant mitigation was required. The joint use resulted from necessity, as the systems grew haphazardly. Therefore, costs of mitigation are not known. For about one mile, a 345 KV transmission line, telephone trunk lines, a gas transmission pipe, a State highway, and railroad tracks all coincide. The telephone trunk lines are within the highway right-of-way, while the gasline is about 25 feet from the transmission towers. This combination of systems has existed for quite some time and no serious conflicts have been reported.

The Detroit Edison study indicates that the technical feasibility problems of joint-use rights-of-way are surmountable where the additional costs due to sharing are necessary and warranted. It further concludes that all major utilities can be accommodated within a common right-of-way ranging in width from 150 feet to 300 feet. However, it must be understood that this study involves a highly developed urban area only 18 miles square and that each use had to be engineered individually and with all recommended safety regulations observed. The study also concludes that alignment of primary highway networks does not normally coincide with that of the utilities. The study indicates that mono-polar operation (ground current return) of a high voltage DC line is unsuitable on shared rights-of-way because of its pronounced corrosion effects. The use of heavy equipment during construction and maintenance is also of particular concern to the safety of adjacent systems and people.

Considerations listed in the Detroit study which influence the design and desirability of common use of rights-of-way are:

1. Safe access for construction and maintenance;
2. Safe working conditions for construction and maintenance of each system;
3. A monitoring system for early detection of faults;
4. Diversified routing, space for future additions, provisions for distribution and corridor crossings;
5. Cost comparison of joint useage vs. separate rights-of-way;
6. How the joint-use right-of-way should be purchased, managed, and maintained;
7. Legal obstacles and legislative changes needed to make land acquisition for common useage practical; and
8. Distribution of right-of-way costs among companies sharing right-of-way.

Another example of joint use involves sharing of railroad rights-of-way which may be the most convenient route, the only practical route, or a major economic advantage. To illustrate, a 138 KV line in Chicago, over seven miles long, is located on the rights-of-way of seven different railroads with crossings over two other railroads. At some points, the base of the towers are only twelve feet from the track center line. Partial sharing of railroad rights-of-way required the acquisition of only an additional 50 foot strip along the railroad right-of-way instead of the 150 foot right-of-way which would normally be required had it not followed the railroad.

The above close sharing required mitigation measures such as moving the railroad signal line to prevent interference from the transmission lines, placing the railroad circuits in shielded cables, and partial replacement with microwave.

When powerlines are located in close proximity to railroads, safety and reliability factors must be considered, particularly in respect to derailed trains damaging electric transmission towers. For safety and reliability, the railroad industry work group report considers it desirable to maintain a minimum distance of one-fourth mile between railroad and electrical systems. Another consideration is that grade and curvature requirements for the two systems are completely different. The normal maximum grade that a railroad can negotiate is about one percent, whereas powerlines are not restricted by grade. Therefore, it is not usually economically feasible for a powerline to follow the railroad's circuitous route. Additional bends and added lengths of powerlines increase their costs substantially. These are problems to be solved when planning a shared right-of-way.

The Federal Highway Administration (FHWA) has approved plans which incorporate rail transit facilities in the median of Federal aid highways. Under present laws, FHWA funds cannot be used to construct such facilities, they can be used to design the highway to accommodate them. However, the 1975 Highway Act under consideration by the Administration would allow funding of rail transit facilities.

There are several instances of joint use by highways and railroads. Rapid transits are located in the medians of the Kennedy, Eisenhower, and Ryan Expressways in Chicago. The recently completed Dulles Airport access road near Washington, D.C., is designed to permit rapid transit facilities in the median.

Highways have been located near or adjacent to railroads and the modes of transportation are considered compatible so long as the limiting factors of design and operation of both transportation systems are recognized. Paralleling of railroads with highways results in increased safety hazards, including more grade crossings. Also, the high-intensity beam of train lights facing on-coming motorists on the highway is a distinct hazard. To minimize such hazards and inconveniences, the American Railroad Engineering Association and the Federal Highway Administration have recommended future cooperative planning.

Experience shows that railroad and pipeline systems can be compatible in close proximity, again as long as the limiting factors of each are recognized. An example is Southern Pacific Pipelines, Inc., a subsidiary of the Southern Pacific Company, which owns and operates approximately 1,358 miles of petroleum-product pipelines of varying size on Southern Pacific Railroad right-of-way. It is not always desirable or feasible to locate systems in close proximity. Of the 2,500 miles of Southern Pacific pipeline, only 1,350 miles of it is located on Southern Pacific Railroad right-of-way, even though most of the pipeline serves the same area as the railroad.

Grade and alignment requirements for railroads do not generally represent the shortest distance between two points and therefore are not considered optimum for pipeline routes. On large cut and fill sections, the railroad may occupy the entire railroad right-of-way, leaving no space for a pipeline. Also, railroads often cross and recross meandering streams in order to maintain curvature and grade limitations. This is not normally desirable for pipelines.

Pipelines are reasonably compatible with railroads, highways, and communication systems; they are least compatible with electrical transmission lines. Powerlines create particular problems because induced voltages and currents are potential shock hazards to personnel in construction, operation, and maintenance of pipelines. Fault currents can damage pipeline facilities; leaks in natural gaslines could cause fires or explosions; and damage or leaks in pipelines could cause washouts, erosion, and flooding of other facilities in or adjacent to the right-of-way.

In addition to problems incurred with electrical transmission lines, other problems result from pipelines sharing other system's rights-of-way. These are primarily in increased route miles, maintenance costs, legal problems and costs, mitigation costs, relocation costs, and design changes resulting from other system conflicts.

In response to an industry work group questionnaire prepared in conjunction with this study, forty-nine pipeline companies reported joint use of highway rights-of-way with parallels up to 539 miles in length, 197 miles along railroads, 280 miles along powerlines, 284 miles along communication lines, and 1,523 miles along other pipelines. Minimum spacing reported ranged from being under the highway shoulder, to ten feet from electric transmission lines, and 75 feet from communication systems. Reasons given for sharing the rights-of-way included ease of acquisition, reduced costs, coinciding routes, land-use and zoning regulations, terrain and other physical considerations, and public acceptance.

Communication systems are reasonably compatible with all systems except powerlines and electrified railroad systems. Long distance communication lines have been placed in joint use with highways, pipelines, electric transmission lines, and railroads. However, these areas of joint use have only been for short distances. The main reasons for separate routing of communication systems are:

1. It has been more economical in construction and maintenence costs;
2. Reduces conflicts in the reliability and safety of the system;
3. The coordination for planning, construction, maintenance, and allocation of costs is less complex with less lead time required;
4. Legal complications are minimized;
5. Safety of personnel and equipment required for the system is significantly improved; and
6. Reduction in mitigating requirements results in more efficient use of materials and labor.

The most critical spacing requirement for communication lines in a joint-use right-of-way is for separation from high voltage transmission lines. Because of this, close parallels have been avoided on transcontinental routes.

The spacing between electric transmission lines and communication lines depends primarily on:

1. Powerline voltage, current, configuration, balance, and wave shape;

2. Coupling between the systems; and

3. The susceptibility of the communication facility to electrical influences.

The communication industry work group report listed examples of seventeen communication and power line parallels ranging in length from 1/5 mile to 40 miles. Separation varied from less than 25 feet to more than a mile and no service problems currently exist. Mitigation costs in two cases were reported to vary from $600 to $6,000 per mile.

There does not appear to be any great incompatibility in joint-use rights-of-way by communication and highway systems, In fact, the Bell System is of the opinion that the option to install communications facilities in highway rights-of-way is in the public interest from an environmental, social, and economic viewpoint. However, the group reported that past practice has been to prohibit longitudinal occupancy of interstate highway rights-of-way by communications facilities.

Six communication and highway parallels ranging in length from 2 miles to 230 miles exist. Distances of separation are from 2 feet inside the roadway to the edge of the highway. However, limited access on interstate highways and safety considerations for workmen have resulted in increased construction and maintenance costs.

Safety is the primary consideration when planning a communication system within a highway right-of-way. The construction and maintenance of communications facilities will at times require the use of heavy equipment whose use and movement can pose a hazard to highway traffic.

Exposure of communication company personnel to high speed traffic while performing normal maintenance work is another hazard, complicated by the fact that if communication facilities are installed in the median strip, access to them will have to be from the high-speed lane.

Environmental impacts will depend on the placement of communication facilities within the limited-access highway right-of-way. If the facilities are installed in the median strip or shoulder of the highway, they will have an insignificant effect on the environment, beyond the effect of the highway itself. The same would be true if they are placed at the edge of the right-of-way, providing the entire right-of-way has been cleared. However, if the sides of the right-of-way have been undisturbed or restored after highway construction, evidence of above-ground communication facilities may be aesthetically unpleasant. Underground lines would, after a period of time, be hidden by natural or supplemented revegetation.

Expansion plans of highway departments and communication companies may interfere with each other. Widening of a highway, the addition of exits, and other work may require relocation of the communication facilities or other measures such as lowering the buried cable or adding to top protection over the cable. Conversion of the communication facility may require disturbing the shoulder of the road or other parts of the right-of-way. These situations will necessitate close coordination between highway and communication officials and are certain to lengthen the planning times for both parties. The problems would, of course, grow more complex if other utilities were involved in the same right-of-way.

Several examples exist of communication lines paralleling railroads, and in eight cases the parallels range from one to 45 miles. Separations of the communication lines from the railroad tracks vary from 20 feet to 170 feet with no service problems reported.

Six communication and pipeline parallels were revealed ranging from 1 1/2 miles to 44 miles in length with separation distances of 25 to 50 feet. No problems between these systems have been reported.

2. Incompatibility

Incompatibility between transportation and utility systems represent a wide array of technical, economical, and social factors.

High voltage electric transmission lines are of varying compatibility with the other systems and are least compatible with the communication and railroad signal systems.

Long parallels of power lines with communication facilities pose one of the most serious threats to the safety of telephone personnel. The electric shock hazard from induced voltages can result in death or serious injury from the shock itself or from the resultant electrical burns. Electrocution and related injuries due to electrical contact are second only to motor vehicle accidents in severity and frequency of all accidents experienced in the Bell System. These risks can be minimized by providing the maximum possible separation between systems, by use of effective bonding and grounding methods, and electrically shielding communications cables in steel pipes.

Electrified railroads cause problems for communication lines similar to those caused by high voltage power lines. The 11-50 KV lines for railroads produce electromagnetic-induced voltages and potential fault currents, though on a much smaller scale than the 500 or 765 KV power lines. Therefore, mitigation methods used to provide compatibility with high-voltage power lines should also be adequate for mitigation of electrified railroad lines; but the reliability of the communication lines would be affected due to the potential for increased outages. Electrified railroads generate high surge currents, much like fault currents on power transmission lines, but on a regular, almost steady-state basis as part of engine starting and switching. These surges could open the overvoltage arrestors on the communication lines and disrupt circuit operations. The extent and severity of the electrical conflicts with railroad systems depend on where, how much, how often, and how long the voltage is induced, and the parameters of the cable, equipment, and power and signal protection systems used. At present, there is no railroad industry standard or accepted practice relating to magnitudes, duration, wave shape, frequency, or probability of occurrence of induced voltages. (Such a standard is being prepared jointly by the Association of American Railroads and the Edison Electric Institute.)

If adequate protection is not provided, a fault from a high voltage power line could burn out a signal system or cause it to malfunction, contributing to a potential train derailment or serious accident. It can also cause noise and voltage interference in the railroad communication system. In addition to the effects of transmission lines on communication and signal systems, there is the added hazard to personnel working on and around the railroad and signal systems. A fault could induce sufficient voltage in these systems to electrocute or seriously injure personnel coming in contact with them.

The pipeline industry work group reports that a significant problem experienced with joint use is the permanence of the right of occupancy of another system's right-of-way. This applies only where the other system has fee title or all property rights to its right-of-way. When a second system is permitted to use part of the existing right-of-way of the first, the second system may have to remove or modify its facilities if the first system decides to expand or increase its capacities. In other words, the second system has questionable tenure within the right-of-way of the first system.

In summary, there are in existence many examples of transportation and utility systems adjacent to or sharing each others right-of-way. Likewise there are many technical, legal, social, and environmental complications to the placement of these systems in close proximity to the same or other systems, particularly for long parallels.

VIII. RIGHT-OF-WAY PROGRAMS AND IMPACTS

Current right-of-way practices of Federal, State, and local governments are discussed in this section. General interrelationships of legislation, regulation, policies, and land-use plans of the various levels of government are considered, followed by a discussion of land committed for rights-of-way. Environmental, social, and economic impacts of rights-of-way are also discussed.

A. Legislation, Regulation, Policies, and Land-Use Plans

1. Introduction

Not only is right-of-way location constrained by technical and economic considerations, it is also limited by legislation, regulations, policies, and land-use plans of various levels of government. The many facets of governmental considerations include, but are not limited to, such items as certification of public convenience and necessity, environmental analyses and impact statements, power of eminent domain, local zoning and planning restrictions, right-of-way specifications, and relocation assistance programs. Since the focus of this study is an evaluation of the right-of-way corridor concepts, this section shall only present those regulations and policies which directly influence right-of-way location. Regulations and policies which control the operation of the system within the right-of-way, and which have only an indirect influence on location, are not explicitly addressed in this study.

The interrelationships of legislation, regulations, policies, and land-use plans among various levels of government, and the agencies within each which regulate the different types of land by ownership and use are very complex. To date, no agency or association -- public or private -- has such a study of these relationships. This implies that it has been more fruitful to examine each individual situation as it arises. An alternative approach is to examine specific cases which would identify interrelationships and problem areas. The major drawback of this approach is its very specificity, which tends to render it inappropriate for generalization. Consequently, this section identifies general interrelationships and problem areas on the basis of readily available information and without the benefit of either prior investigations by other agencies or associations, or in-depth case studies.

The following discussion is based upon the Daniel, Mann, Johnson, and Mendenhall work, Federal Public Land Law and Policies Relating to Use and Occupancy (1970) prepared for the Public Land Law Review Commission; Federal Energy Regulation: An Organizational Study by the Federal Energy Regulation Study Team (April 1974); a review of the public land laws and regulations; correspondence with the State BLM Offices; and communications with the National Association of Regulatory Utility Commissioners, the National Governors' Conference, the Council of State Governments, and the National Association of Counties.

2. The Federal Aspects

a. Land Management Regulations and Policies

(1) Department of the Interior

The Secretary of the Interior is authorized to permit the use and occupancy of public lands for specified purposes, including transportation and utility rights-of-way. "Rights-of-way" as defined in the Code of Federal Regulations include licenses, permits, or easements as used in the authorizing statutes.

The Secretary of the Interior has delegated to the Bureau of Land Management (BLM) the authority to issue and administer rights-of-way across public lands administered by it. Thus, BLM is responsible for issuing rights-of-way for electric transmission, communications, pipelines, railroads, and highways on the land that it administers (National Resource Lands) and, in the cases of oil and gas pipelines, national forest lands reserved from the public domain.

Where the land over which the right-of-way is sought is withdrawn or reserved for the use of another Federal Agency, the BLM is required to coordinate the application with that agency. Whenever a right-of-way is sought across national forest lands or any area withdrawn for inclusion within national forests, the applicant must enter into such stipulations as the Forest Service may require for the protection of the national forest.

BLM right-of-way policy has evolved over time. While the granting of a right-of-way is discretionary, the BLM Manual (5 S3.8.5, Release No. 196, 1960) states that it is the policy of the Bureau, to the extent that it is in the public interest, to grant requested rights-of-way as promptly as possible and with as few restrictions as possible, since the granting of rights-of-way is essential to the proper use and development of public and private lands. However, a later instruction memorandum (No. 64-46, January 27, 1964) states that, because of increasing demands for rights-of-way, planning and management of rights-of-way is encouraged to avoid excessive demands on fixed or diminishing resource bases and to protect aesthetic values. The number and size of permits are to be held to a minimum, and dual or multiple-use rights-of-way maximized. For oil, gas and petroleum products pipelines, P.L. 93-153, passed in November 1973 formalized this policy as follows:

> In order to minimize adverse environmental impacts and the proliferation of separate rights-of-way across Federal lands, the Utilization of rights-of-way in common shall be required to the extent practical . . . (emphasis added).

Rights-of-way across lands administered by the Fish and Wildlife Service, primarily National Wildlife Refuge System land, are issued by the Director of Fish and Wildlife Service. The major criterion used to assess each right-of-way is its compatibility with the management objectives of the refuge area. The regulations, themselves, are the same as those on National Resource Lands.

The Secretary of the Interior is specifically authorized to grant leases, easements, and licenses for use of lands or interest in lands withdrawn and administered under the Federal reclamation laws in connection with the construction or operation and maintenance of any project. Rights-of-way easements or contract licenses on reclamation lands are granted by the Regional Directors of the Bureau of Reclamation. The major condition attached by the Bureau of Reclamation is that the applicant does not interfere with Reclamation's use of the land.

(2) Department of Agriculture

Permits and easements for transportation and utility rights-of-way across national forest lands are granted by the Forest Service except on national forest lands reserved from the public domain where the BLM has authority to issue oil or gas pipeline rights-of-way. This amounts to approximately 160 million acres nationwide or about 86 percent of the lands administered by the Forest Service. Under an interdepartmental agreement, the BLM rquests Forest Service recommendations: (a) as to issuance of leases or granting rights-of-way; and (b) for

for suggested special stipulations needed to protect national forest surface resources. The Secretary of the Interior is not required by law to observe the Forest Service recommendations, but the general policy is to do so.

A different situation exists with regard to national forest lands acquired by the United States through purchase, exchange, and donation and in which the mineral rights are also federally owned. In such cases, leases and permits are subject to such conditions as the Secretary of Agriculture may prescribe to insure the adequate utilization of the lands for the primary purposes for which they were acquired or are being administered.

The general policy of the Forest Service is to grant easements only when it is consistent with the public interest. If the granting of an easement is found to be undesirable or contrary to the public interest, or if there is no authority for granting an easement, consideration is given to authorization by terminable special-use permit. Department of Agriculture regulations provide that all uses of National Forest lands, improvements, and resources are designated as special uses and authorized by special use permits.

Since the Secretary of the Interior has not been given general authority to grant rights-of-way for oil and gas pipelines across acquired lands, the Secretary of Agriculture has been given this authority for lands acquired under Title III of the Bankhead-Jones Farm Tenant Act. These lands generally comprise the national grasslands.

Right-of-way regulations and conditions for the agencies discussed up to this point are summarized in Table VIII-1.

(3) Department of Defense

The Secretary of each department within the Department of Defense is authorized to grant easements or rights-of-way across land under his jurisdiction, upon a finding that it will not be against the public interest. The purposes for the easements include roads, canals, gas, water, and sewer pipelines.

The Corps of Engineers is charged by Section 10 of the River and Harbor Act of March 3, 1899, to prohibit the unauthorized obstruction or alteration of any navigable waters in the United States. The granting of permits for right-of-way crossings are included in its purview.

TABLE VIII-1

RIGHT-OF-WAY REGULATIONS AND CONDITIONS

	BUREAU OF LAND MANAGEMENT	BUREAU OF RECLAMATION	BUREAU OF SPORT FISHERIES & WILDLIFE	FOREST SERVICE
Electric Transmission	43 CFR 2800; 2850 Width: 100' (1901); 400' (1911) Discretionary	Instructions. Chap. 215.4.1 Width: see BLM Discretionary	50 CFR 29.21 (43 CFR 2850) Width: see BLM Discretionary	36 CFR 251.5; FSM 2703, 2728, 2728.12 Width: 100' (1901); 400' (1911) Discretionary
Communications	43 CFR 2800; 2860 Width: 100' (1901); 400' (1911) Discretionary	Instructions, Chap. 215.4.1 Width: see BLM Discretionary	50 CFR 29.21 Width: see BLM Discretionary	FSM 2703, 2728, 2728.2 Width: 100' (1901); 400' (1911) Discretionary
Pipelines	43 CFR 2800; 2880 Width: 50' plus ground occupied Discretionary	Instructions. Chap. 215.4.1 Width: see BLM Discretionary	50 CFR 29.21 Width: see BLM Discretionary	FSM 2703, 2728, 2728.11 Width: 20' Discretionary
Railroads	43 CFR 2800; 2840 Width: 200' Discretionary	Instructions. Chap. 215.4.1 Width: see BLM Discretionary	50 CFR 29.21 Width: see BLM Discretionary	FSM 2703, 2728, 2727.15 Width: 200' Discretionary
Highways	43 CFR 2800; 2820 Width: Minimum necessary Discretionary	Instructions. Chap. 215.4.1 Width: Minimum necessary Discretionary	50 CFR 29.21 (43 CFR 2820) Width: Minimum necessary Discretionary	FSM does not grant easements for Federal aid system but gives consent to the appropriation and transfer of its lands for highway purposes.

In evaluating each permit, the Corps of Engineers considers (1) public and private needs, (2) the desirability of alternative locations and methods, (3) the extent and permanence of effects, and (4) the probable impact of the project relative to the cumulative effect of all other activities existing and proposed in the area.

(4) Other Concerned Agencies

The Federal Power Commission (FPC) has regulatory responsibilities with regard to electric power and natural gas sold in interstate commerce. Among other responsibilities, the FPC issues and administers permits and licenses for construction and operation of non-Federal hydroelectric projects on water or lands subject to Federal jurisdiction. It also issues permits for the construction and operation of interstate gas (not oil) pipelines and storage facilities used in conjunction with such pipelines. In determining whether a permit should be granted, the FPC takes siting and land use into account.

Communication systems must apply for a construction permit from the Federal Communications Commission (FCC) as well as a land-use permit from the land managing agency involved. The FCC then issues either a construction permit or a temporary authorization to test the feasibility of the proposed operation. When such an application is made to BLM, either a right-of-way permit is issued or, if FCC authorization is limited to a testing period, a temporary right-of-way permit is issued, pending issuance of a communications license. FCC licensing criteria require that issuance of a license be in the public interest.

While the rate setting and common-carrier responsibilities of the Interstate Commerce Commission (ICC) extend over both railroads and oil pipelines, it is only to a limited extent concerned with rights-of-way. The ICC is authorized to issue permits for railroads to either extend or abandon service. To the extent that the ICC permits the extension of service, it influences the general area in which new rights-of-way may be acquired. The ICC, however, licenses neither the construction nor the operation of pipelines.

The Nuclear Regulatory Commission (NRC) regulates the siting and licensing of nuclear power plants and thereby controls the point of origin from which the electric transmission lines will extend to the transmission grid. The NRC requires that nuclear plants have reliable shutdown power from two independent sources. However, the NRC has no direct responsibility relative to transmisison line locations.

Three agencies in the Department of Transportation with responsibility in the area of transportation safety are the Office of Pipeline Safety, the Federal Railroad Administration and the National Transportation Safety Board.

The Office of Pipeline Safety authority is derived from the Natural Gas Pipeline Safety Act of 1968, and the Transportation Act of 1966. It promulgates and enforces safety regulations for pipelines that transport gas and petroleum products in interstate commerce. The Department also has been assigned responsibility for pipeline safety under the following Acts: The Hazardous Materials Transportation Act; Deepwater Port Act of 1974; and section 28 of the Mineral Leasing Act of 1920, as amended by the Act of November 16, 1973. The Federal Railroad Administration similarly promulgates and enforces regulations to protect railroad workers and the public from hazards associated with rail transport. Under certain circumstances these two Agencies may influence, but not dictate, right-of-way locations relative to other nearby existing and proposed rights-of-way.

The National Transportation Safety Board, created in 1966, has as its primary responsibility the promotion of safety in all modes of transportation -- civil aviation, highway, marine, railroad, and pipeline. Based on accident reports and special studies the Board independently recommends what could be done more effectively. The Board has no regulatory or enforcement authority, but depends on publicly-stated recommendations to prompt others to take corrective measures. These recommendations could result in changes in the policies of various agenices and industries.

b. Legislation

In the past 125 years there has been a plethora of legislation concerning utility and transportation rights-of-way on public lands. The following is a brief chronological outline of major existing legislation.

Federal Highway Grant Act -- Act of July 26, 1866
ch. 262, 14 Stat. 251, Rev. Stat. 2339, 2477 (1878)
30 USC 43, 46, 51; 43 USC 661, 932.

Right-of-way for construction of highways over public lands is granted where not in conflict with other public uses.

General Railroad Right-of-Way Act -- Act of March 3, 1875, ch. 152, 18 Stat. 482, 43 USC 934-939.

This act grants rights-of-way to the railroads through public lands. Procedures are established for condemnation of private lands and the determination of possessory claims on public lands. Provision is made for forfeiture rights. Military, park, or Indian reservation lands are specifically reserved.

Act of June 4, 1897 and Act of February 1, 1905, 16 USC 551 and 16 USC 472, respectively.

These acts provide the basic authority for the Forest Service to grant annual special use permits.

Act of March 3, 1899, ch. 427, 30 Stat. 1233, 43 USC 665, 958, 16 USC 525.

The Secretary of the Interior may file and approve surveys and plats of rights-of-way for roads, railroads and highways on forest reservations or reservoir sites.

River and Harbor Act of March 3, 1899, 30 Stat. 1151, 33 USC 403.

Prohibits the unauthorized obstruction or alteration of any navigable water in the United States. Requires permits from the Corps of Engineers for crossings. However, when such permits are part of a water power project subject to the regulatory authorities of the FPC under the Federal Water Power Act of 1920, (16 USC 797) application is made to FPC.

Act of February 15, 1901, ch. 372, 31 Stat. 790, 43 USC 959, 16 USC 79, 522.

The Secretary of the Interior may grant rights-of-way through specified forests and other reservations for purposes of communications, distribution of power, and commercial production, subject to approval where required, and retaining a right of revocation.

Act of March 4, 1911,
ch. 238, 36 Stat. 1253, as amended by Act of May 27, 1952,
P.L. 367, ch. 338, 66 Stat. 95. 43 ISC 961, 16 USC 5,420,523.

Rights-of-way for purposes of communication and the transmission of electric power may be granted by the department head having jurisdiction over public lands, including national parks, national forest, military, Indian or other reservations of land, subject to forfeiture for nonuse.

Mineral Leasing Act of 1920 -- Act of February 25, 1920,
as amended, P.L. 93-153 November 16, 1973, 87 Stat. 576.,
30 USC 185.

Oil and gas pipeline rights-of-way through any Federal lands may be granted by the Secretary of the Interior. Right-of-way width shall not exceed 50 feet plus the ground occupied by the pipeline. Joint use of the right-of-way shall be required to the extent practical.

Federal Power Act of June 10, 1920
As amended, Act of August 26, 1935, 49 Stat. 838, 16 USC 791-825r.

Application for hydroelectric power plant sites or rights-of-way for main or primary hydroelectric transmission lines must be made to the Federal Power Commission.

Bankhead-Jones Farm Tenant Act of July 22, 1937,
as amended, 7 USC 1010-1012.

Title III allows for the issuance of licenses and easements for oil and gas pipeline rights-of-way across lands purchased under this authority.

Reclamation Project Act of 1929 -- Act of August 4, 1939,
as amended, 43 USC 375a, 387-389, 385k.

The Secretary of the Interior may permit the removal of minerals, grant leases and easements, sell certain lands, and enter into contracts for services and supplies. When appropriations have been made for commencement of construction of the project, the Secretary may purchase land for relocation of highways, railroads, and transmission lines, and contract for exchange or replacement of water or electric energy.

Act of May 9, 1941,
ch. 94, 55 Stat. 183, 43 USC 931a.

The Attorney General may grant easements over lands in the public domain; jurisdiction over the areas covered by such easements is added to the States in which the lands lie.

Act of September 13, 1951,
ch. 382, 65 Stat. 321.

The Secretary of the Navy may grant specified easements for highways, sludge, force mains, telegraph lines and overhead transmission lines.

Act of August 10, 1956,
10 USC 2668.

If the Secretary of a military department finds that it will not be against the public interest he may grant easements for rights-of-way for (1) railroads; (2) oil pipelines; (3) substations for electric power transmission and communication lines and pump stations for gas, water sewer and oil pipelines; (4) canals; (5) ditches; (6) flumes; (7) tunnels; (8) dams and reservoirs in connection with fish and wildlife programs; and (9) roads and streets.

Act of August 27, 1958,
72 Stat. 892, 23 USC 107d.

Whenever rights-of-way on the interstate system are required over lands or interests in lands owned by the United States, the Secretary of Transportation may make such arrangements as may be necessary with the agency having jurisdiction over such lands.

National Historic Preservation Act of June 27, 1960,
as amended, Act of May 24, 1974, 88 Stat. 174, 16 USC 469.

Whenever any Federal agency finds, or is notified in writing by an appropriate historical or archaeological authority, that its activities in connection with any Federal construction project or a federally licensed project, activity or program may cause irreparable loss or destruction to significant archaeological data, every effort should be taken to recover, protect and preserve such data.

Act of October 13, 1964,
78 Stat. 1089, 16 USC 533.

The Secretary of Agriculture is authorized to grant easements for road rights-of-way (1) over national forest lands and other lands administered by the Forest Service, and (2) over any other related lands with respect to which the Department of Agriculture has rights under the terms of the grant to it.

National Wildlife Refuge System Administration Act of 1966 -- Act of October 15, 1966,
80 Stat. 929, 16 USC 668 dd.

The Secretary of the Interior may grant easements in the refuge system for purposes such as powerlines, telephone lines, pipelines and roads whenever he determines that such uses are compatible with the purposes for which these areas are established.

National Wild and Scenic Rivers Act, Act of October 2, 1968,
82 Stat. 906, 16 USC 12171.

The Secretary of the Interior or the Secretary of Agriculture, as the case may be, may grant easements and rights-of-way in accordance with the laws applicable to the national parks and the national forest, respectively: Provided that any conditions precedent to granting such easements and rights-of-way shall be related to the policy and purpose of this act.

3. The State Aspect

Until recently, little was done by the States to control the location of transportation and utility rights-of-way. Certificates of public necessity and convenience, as well as permits, are generally the responsibility of a State regulatory agency such as a public utility commission or public service commission. A listing of such commissions for the Western States is presented in Figure VIII-1. These commissions typically are involved with rate setting, financing, and public welfare, and have not usually been concerned with the specific site location of rights-of-way.

FIGURE VIII-1

REGULATORY AGENCIES FOR THE WESTERN STATES

Arizona Corporation Commission, Phoenix
California Public Utilities Commission, San Francisco
Colorado Public Utilities Commission, Denver
Idaho Public Utilities Commission, Boise
Montana Public Service Commissioners, Helena
Nevada Public Service Commission, Carson City
New Mexico Public Service Commission, Santa Fe
North Dakota Public Service Commission, Bismarck
Oregon Public Utilities Commission, Salem
Utah Public Service Commission, Salt Lake City
Washington Utilities and Transportation, Olympia
Wyoming Public Service Commission, Cheyenne

Subsequent to the National Environmental Policy Act, many States have either enacted or are attempting to enact legislation to control the locations of rights-of-way, most notably transmission lines. Figure VIII-2 summarizes the extent of such involvement by the Western States, in terms of developing comprehensive land-use plans, environmental protection, and State and local regulations on utility sitings.

The data summarized in Figure VIII-2 was obtained by BLM field personnel through contacts with State officials. It is noteworthy that there is continuous legislative activity occuring in most States regarding land-use planning, environmental protection and utility siting.

4. Local Aspects

Information developed through contacts by BLM State Offices indicates that to date there has been little concerted effort by Western counties to control the location of rights-of-way. The two complimentary tools which are sometimes used by counties are land-use plans and zoning. Given the great number of counties in the Nation and a tendency for changing policies to meet local conditions, it is very difficult to predict what may be anticipated at this level.

FIGURE VIII - 2

SUMMARY OF STATE LEGISLATION AND POLICIES AFFECTING RIGHTS-OF-WAY FOR THE WESTERN STATES

State	Comprehensive Land-Use Planning	Environmental Protection	Utility Siting
ALASKA	A joint Federal-State Land Use Planning Commission was established in 1972. This was a coordinated approach to land-use planning for future use of the public land base in Alaska.		
ARIZONA		- The Environmental Planning Commission provides guidelines on land-use planning. - An Environmental Impact Statement is required for proposed electric transmission lines. - The Urban Environmental Management Act of 1973 establishes planning and zoning regulations for cities and towns.	- State regulations exist for power plant siting and transmission line location. - Electric companies are required to file 10 year plans for the effects on the environment. - Common carrier law requires the registration of pipelines within the Arizona Corporation Commission.
CALIFORNIA		- Environmental Quality Act of 1970 is similar to NEPA. - An Environmental Impact Statement is required for all State projects with significant effects on the environment, including all 230 KV or greater transmission lines.	- Certificate of public conveniences and necessity is required for all 230 KV lines and greater.
COLORADO			- Certificate of public convenience and necessity is required for all electric and gas lines. - Wheeling regulations can require sharing of the electric transmission rights-of-way to avoid duplication of facilities. - There is no similar policy for pipelines. - Provisions for adjusting right-of-way rental rates to induce sharing of rights-of-way.

(continued)

State	Comprehensive Land-Use Planning	Environmental Protection	Utility Siting
COLORADO (continued)			- Colorado Division of Highway policy is to permit electric transmission and communication lines to share the highway rights-of-way. - Local Land Use Control Enabling Act of 1974 permits local governments to become involved in the regulations of utility and transportation corridors.
IDAHO			- Public Utilities Commission approved permits for proposed utility lines on an individual basis.
MONTANA		- The Montana Environmental Act of 1971 was modeled after the National Environmental Policy Act.	- Department of Natural Resources has authority to grant electric power permits under the Utility Siting Act of 1973. Legislation is pending to extend this authority to all electric power lines and pipelines.
NEVADA	- Land Use Planning Act of 1973 provides for the development of a land-use planning program in 1975-77 to identify critical environmental areas and to require Environmental Impact Statements.	- The Utility Environmental Protection Act of 1971 provides for evaluation of the competing demands for resource allocation and requires approval by the Public Service Commission of proposed utility facilities.	- Public Service Commission approves the siting of utilities. - Colorado River Commission has a role in locating utility corridors in part of the State.
NEW MEXICO		- The Environmental Protection Act of 1972 was repealed in 1974. - An Environmental report is required for proposed utility projects.	- Public Service Commission requires a certificate of public convenience and necessity for electric transmission lines of 230 KV or greater. - There is no State regulation on pipeline locations. - State Highway Commission has a policy to maximize public use of highway rights-of-way by the utilities, subject to State Highway Department regulations. - New Mexico Energy Corridor Study is in progress to refine the pattern that should be taken by utility corridors.

State	Comprehensive Land-Use Planning	Environmental Protection	Utility Siting
OREGON	- Comprehensive land use measures were enacted in 1973.		- There is no general control of right-of-way locations at the State level.
UTAH	- A legislative proposal failed to be ratified by the voters in 1974.	- State agencies are required to file an environmental Impact Statement for actions taken.	- There is no general control of right-of-way locations at the State level.
WASHINGTON		- The Environmental Policy Act of 1971 parallels the National Environmental Policy Act.	- The Shoreline Management Act of 1972 regulates the use by utilities of land adjacent to the ocean and large lakes and rivers. - Thermal Power Plant Siting Act of 1970 regulates the siting of electric power plants and transmission lines.
WYOMING	- The State Land Use Planning Act 1972 requires, among other things, the development of land-use plans at the State and local level.		- Public Service Commission issues licenses for utility lines.

B. Rights-of-Way - Present and Anticipated Trends

1. Present Situation

In the effort to determine the extent of the right-of-way program in the United States, it was found that no one source had all the necessary information. The data that was gathered from numerous sources was so varied and so incomplete that any attempt to compile it in a meaningful manner would have been futile.

For example, the information gathered for highways indicated that there are approximately 3.8 million miles of streets, roads, and highways in the United States. The width of the rights-of-way were not given but they would range from about 50 feet to 300 feet. Since no data was available as to the number of miles for a specific width right-of-way, any attempt to derive acres would necessitate assuming an average right-of-way. A two-foot difference in assumption of such a figure would result in a difference of nearly a million acres.

The above example, coupled with similar incomplete data for the other systems, clearly points out the difficulties in attempting to accurately determine the extent of the total right-of-way program in the United States. Any such total would have to be based on so many assumptions that the result would be meaningless.

Acknowledging the above limitations, available nationwide data, coupled with right-of-way width assumptions approximates the acreage encompassed by the major facilities of each system included in the scope of this study. Table VIII-2 indicates that over 16 million acres of land is encompassed by rights-of-way on a nationwide basis for all types of systems included in this report.

Due to the manner in which each Federal Agency keeps its right-Of-way records, it was not feasible to determine accurately the present number or acreage of rights-of-way granted on Federal lands for the systems within the scope of this study. Records are kept on a case-by-case basis and are not segregated by type.

An important factor to consider with regard to land commitment is the percent of land that a right-of-way actually takes out of previous land use. Nearly 100 percent of the land within a power transmission line, pipeline, and communication line right-of-way is available for previous land use after the facility is constructed, except for such uses as timber production. The easements for the rights-of-way constrain certain types of noncompatible uses, but in general prior

TABLE VIII-2

APPROXIMATE MILEAGE AND ACREAGE OF MAJOR FACILITIES BY SYSTEMS

ELECTRIC TRANSMISSION (1974)

Voltage	Circuit Miles	Assumed R/W-ft.	Approximate Acres
115 KV-161 KV	178,473	75	1,624,936
230 KV	55,470	100	672,363
345 KV	38,407	150	698,309
500 KV	13,451	180	293,476
765 KV	1,139	210	28,993
800 KV dc	865	150	15,727
TOTAL	288,075		3,333,804

Assumed R/W widths for 115, 230, and 345 KV are reduced to reflect a substantial amount of double circuit construction. Circuit Miles from FPC News Release No. 21206, March 12, 1975.

PIPELINES

	Miles	Assumed R/W-ft.	Approximate Acres
Crude and Refined Products Trunk Lines (1974)	153,089	50	927,812
Natural Gas Transmission (1973)	265,200	50	1,607,272
	418,289		2,535,084

Narrow right-of-way width used because looped pipelines using shared right-of-way are included in total-mileage.

COMMUNICATIONS (1974)

	Miles	Assumed R/W-ft.	Approximate Acres
Regional and Trans-continental Lines	20,000	40	96,970

HIGHWAYS (1974)

	Miles	Assumed R/W-ft.	Approximate Acres
Interstate	42,500	250	1,287,878
Primary	228,959	125	3,469,075
	271,459		4,756,953

RAILROADS (1974)

	Miles	Assumed R/W-ft.	Approximate Acres
Class "A"	234,000	200	5,672,726

	Miles	Assumed R/W-ft.	Approximate Acres
TOTAL (ALL SYSTEMS)	1,231,823		16,395,537

uses can and do continue. Highways and railroad rights-of-way generally constitute a complete taking of property rights so previous land uses are not allowed in the right-of-way.

2. Anticipated Trends

Continuing increases in the per capita consumption of energy by the American populous requires increased development of our energy resources.

The President's "Project Independence Program," to make the United States self-sustaining by 1985 envisions:

200 major nuclear power plants;
250 major new coal mines;
150 major coal-fired power plants;
30 major new oil refineries;
20 major new synthetic fuel plants; and
the drilling of many thousands of new oil wells.

Realization of such a far-reaching program will require comparable growth in the transportation and utility systems, including additional rights-of-way. It will require the linking of coal, oil and gas fields, etc. with market areas. Such linkage will be either through physical movement of energy resources for power generation or petroleum refining or from on-site energy development followed by transportation to market. The extent and timing of such development cannot be accurately predicted at this time.

Reports such at the Northern Great Plains Study, 1974, by the Department of Interior and the Project Independence Report, 1974, by the Federal Energy Administration estimate the quantities of energy resources to be transported from organic fuel deposit areas in the next 10 years. However, these estimates are dependent in part on priorities or emphasis of Federal policies. For example, the FEA's Project Independence Report indicates that about 17 percent of coal comes from the Western coal fields in the Northern Great Plains, Rocky Mountains, and the Pacific Coast where the majority of the Federal lands are. The report states that demand levels for the next 10 years are not projected to bring about massive development of the Western coal fields. However, if the demand for low sulphur content coal is increased significantly, coal from Western coal fields could increase accordingly. This study will not attempt to analyze the quantities estimated in such energy reports. It will, however, recognize the potential for energy resource development without attempting to anticipate when, where, and to what extent such development would occur.

Industry projections indicate minimal growth of future rights-of-way for primary highway, railroad, and communication systems. However, it is expected that there will be a significant need for additional rights-of-way for electric transmission and pipeline systems.

C. Social and Economic Impacts

1. Introduction

The importance of the transportation and utility industries to society is evidenced by the increased per capita consumption of the commodities and services provided by them, the growing dependence of the public on these commodities and services, and the limited supply of energy resources. As noted previously, the only systems that will experience significant growth will be the electrical and pipeline systems. Consequently, these systems will be discussed in more detail than the others. The opportunity for continued growth of these systems is not only socially and economically desirable, but it is essential to the welfare of the Nation. However, the impact of right-of-way locations is relative to how and to what extent the social, economic, and cultural consideration of the area are affected.

Although the scope of this study relates specifically to Federal lands, social and economic impacts apply to the entire length of a right-of-way from the point of origin to the destination. Acres around Federal land are generally sparsely inhabited and intensive developments minimal or nonexistent, therefore, social and economic impacts of the systems are of greatest significance in populated, intensively developed non-Federal areas. It is therefore necessary to assess not only the social and economic impacts of rights-of-way on Federal lands, but also the more significant non-Federal land areas.

2. Socio-Economic Considerations in Right-of-Way Locations

In weighing alternative route locations for a given right-of-way, the amount of land devoted to specific uses and the size of the population that will be affected by segments of a proposed system can be important indicators of the relative effects which different routings may have on the human environment.

Socio-economic and cultural factors can represent important constraints on the choice of right-of-way routings. Land-use constraints are manifested in policies and public pressure to avoid archeological and historic sites and monuments, to preserve scenic and unique areas, and to minimize interference with points of congestion. Many public hearings and court actions have revolved around the question of aesthetic compatibility or visual harmony between utility lines and their surroundings. The problem of noise also arises in the form of electromagnetic interference to radio and TV reception, audible noise from power lines, and the high decibel levels of pipeline booster stations.

In locating a right-of-way, aesthetic considerations may be employed to minimize the potential incompatibility of a system with surrounding land uses. However, to some degree, the aesthetic impact of any visual change in the environment will always involve subjective judgment. This fact is evidenced by such events as the occasional lawsuit intended to prevent construction of a house regarded by the plaintiff as "not fitting," although the defendant has paid to have it designed as a thing of beauty. Similarly, the objection to locating a right-of-way system next to a residential or a scenic area may depend to some extent on the visual disharmony which it creates. Utility lines can detract from other visually satisfying elements by destroying the continuity of the landscape by the intrusion of cleared space and manmade structures. The width of joint-use corridors and the presence of ground structures may be difficult to hide and are often deemed obtrusive. Visual effects, both the magnitude of disharmony produced by a right-of-way and the extent of the resulting impact on the viewers, can be quantified in terms of:

1. The number of viewers exposed to the line or right-of-way;

2. Duration and frequency of exposure;

3. Linear distance over which any segment of the line is visible from a specified viewing point;

4. Distance from the viewer; and

5. Extent or percent of viewscape dominated by the system.

While the above means of quantification are useful, particularly for comparing alternative right-of-way locations, they take neither the total visual impact nor the visual quality of the land into account. The psychological impact of right-of-way location on a community depends primarily on how thoroughly the utility proponent conducts its planning and preliminary location preparation. Few communities will readily welcome a utility line passing by or through them. The strength of community opposition and its distress in terms of perceived effect on lifestyle depend on the proponent's effort to (1) acquaint the public with what is planned; (2) work harmoniously with local regulatory bodies; and (3) create an opportunity for public participation in determination of the right-of-way location.

Few linear construction projects will significantly affect a community in respect to its capacity to provide educational and medical facilities or police and fire protection.

Not all desirable features can be simultaneously realized in right-of-way location. Often a choice must be made among land uses, of which all have some element of incompatibility. Routing a line through a particular rural region may involve disruption of agriculture or disturbance of scenic and cultural values. The routing that represents the least impact depends on the point of view taken as to the relative value of land for agricultural use in contrast with cultural and recreational purposes. Conflicting viewpoints also surface in the trade-off between routing a line within or adjacent to a highway and a separate remote location.

Public acceptance of a right-of-way is closely linked to the types of land use adjacent to the proposed right-of-way location. In considering the potential impact of a line in any specific location, the present land use is important along with what is planned for the future. In some situations, zoning regulations may pose a binding constraint; in others, they serve to designate the use of the land affected. Therefore, the aid of local and regional planning agencies is invaluable in right-of-way siting studies. By working with planning agencies, a shared data base may be available for use and rights-of-way needs can be integrated into land-use planning and policy formulation.

3. Rights-of-Way Effects On Area Growth and Development

Quantitatively, the amount of land that is denied to other uses after a pipeline or electric transmission line has been constructed is quite small. For pipelines, right-of-way width requirements during construction may be as much as 100 feet. The amount of space that must be kept cleared of shrubs and trees after the pipeline is constructed typically ranges between 25 and 65 feet, or an average of about five acres per mile. This right-of-way is essentially unobstructed except for markers and occasional above-surface structures, and may be available for recreational facilities such as hiking trails. Right-of-way widths for electric transmission lines, while greater than for pipelines, are also small in terms of land used per mile of line. The area within the right-of-way is potentially available for multiple use except for land occupied by poles or towers. For most voltage levels, nearly 100 percent of the right-of-way area is available for multiple use. It must be kept in mind, however, that both powerline and pipeline easements prevent noncompatible uses such as homes and other buildings within the right-of-way.

While the capability exists to construct utility systems across almost any type of land, there are technical, environmental, and economic considerations which will influence the location of a particular system. For example, range and pasture lands are subject to less use interference from a utility system than are irrigated croplands and forested areas. In using recreation or conservation land areas, care must be taken to prevent altering significantly the character of the land. Likewise, in the use of commercial and industrial land, safety is an important consideration.

Problems in locating rights-of-way in urbanized areas are a function of population density or developmental intensity. Because of extensive existing development, the potential locations for any rights-of-way are limited. That is, the availability of land within an urbanized area may become a crucial determinant in a joint-use location, while practicality, aesthetics, costs, and ease of operation and maintenance may be relegated to a secondary consideration. Right-of-way construction in an urban area may require the removal of structures or inhibit or conflict with other urban construction and development, which may present a possible economic loss to the community. In addition, land purchased in an urban area will generally be more costly for the utility company than land in a rural area.

Transportation corridors have been publicly opposed on the grounds that they may bisect a community. However, utility corridors normally do not impede movement and are less likely to create physical boundaries than highways and railroads. It it unlikely that such utility lines will split neighborhoods or communities or destroy the social, cultural, or economic unity of a given area.

Rural areas, in comparsion with urban areas, exhibit fewer impediments to rights-of-way location since there are fewer manmade obstacles. Single ownership of large tracts of land generally renders land-use arrangements for rights-of-way more easily obtainable. However, the creation of electromagnetic interference by transmission lines may become an important factor since television and radio reception is generally weaker in rural areas and therefore more easily disrupted.

It is possible that some of the opposition directed towards utility line location may be created more by fear of change than by the actual impact. For instance, a utility line through an established residential area may be adamantly opposed because of the fear that there will be a great deal of aesthetic impact or that neighborhood unity and land values may be destroyed. However, there is little clear evidence to indicate that additional rights-of-way actually decrease land values. In fact, there is an absence of documentation to substantiate the idea that prospective purchasers, either of existing homes or in a new development, are discouraged by the presence of utility rights-of-way.

Social concerns often reflect the feeling that the people affected had no chance to influence the result of right-of-way decisions. Better results can be expected when the affected citizenry is alerted early in the planning process, giving them an opportunity to call attention to local factors in time for consideration. Therefore, it is important that a continuing dialogue be established between the utility representatives, official regulatory bodies, and the public. Opposition should not be discouraged at an early date, for only through this process can it be assured that all reasonable alternatives be given adequate consideration and that all factors are fully considered.

D. Environmental Impacts

1. Introduction

Public concern for better planning and use of our natural and cultural resources has caused enactment of numerous laws, regulations, and policies at Federal and State levels of government. The most prominent among these is the National Environmental Policy Act (NEPA). In the planning and route selection process, the NEPA procedures and requirements generally provide a thorough assessment of environmental, social, and economic impacts resulting from any major Federal action.

Full coordination between levels of government - Federal, State, and local - to evaluate and minimize environmental impacts is not yet practiced. The reasons can be attributed in part to the different perceptions of "public interest" exhibited by well-meaning individuals at all levels. After considerable investigation, it became apparent that no framework exists within which full coordination can function.

2. Construction

During the life of any system, the most notable environmental impacts occur during the construction phase. The impacts are related to vegetation, soil, aesthetics, and air, water, and noise pollution.

The construction of electrical and overhead communication systems does not normally require removal of all right-of-way vegetation. If trees are present, only those that could come into flash-over distance with the lines or tower, or would be in the way of access roads are removed. The highway, railroad, pipeline, and buried communication systems normally require removal of most vegetation in the right-of-way prior to construction activity. There is a trend to leave selected trees along highways for aesthetic purposes providing that they are not safety hazards. Unfortunately, nearly all construction involves some erosion. Construction of electrical and overhead communication systems does not require soil disturbance in the right-of-way except at the tower sites, sites for fabrication and installation of the facilities, and for access roads. Most top soil in highway and railroad rights-of-way is removed during construction activity. However, there are often areas along the outer edges of these rights-of-way that are not disturbed. For pipelines and buried communications systems, it is necessary to grade nearly the entire right-of-way in order to allow efficient equipment operation.

Water quality, too, is affected by construction activity. Increased sediment or other pollutants adversely affect all acquatic species. Air quality is temporarily lowered in the construction area by dust particles and vehicle and other equipment emissions. This dust is not only physically unpleasant, coating surrounding areas, but is visually unpleasant as well. And, moreover, it can temporarily affect the growth and palatability of local vegetation. This impact on vegetation is, reduced by rainfall, and, in some instances, by applying water on the surface. Construction noise from equipment and blasting can also be a severe, but short-lived impact on wildlife and humans.

Unfortunately, due to their linear nature, there is no way that right-of-way construction activities can entirely avoid leaving visible scars. Even following restoration and revegetation, abrupt change from the surrounding visual pattern is evident, and when this change occurs in an area where man's activities are not evident, it often adds a discordant line that attracts the viewer's attention. For example, swaths cut through timber and abrupt conversion of heavy shrub cover to grass and forbs are noticeable for miles. The impact of such lines on the landscape can be high or low depending on terrain, cover, and the presence or absence of roads, fences, farm fields, and other rights-of-way.

All of these construction impacts can be lessened through mitigation practices that are spelled out as stipulations in Federal right-of-way grants. This, however, can only be accomplished in practice if the resource and environmental inventories are complete, and mangement goals have been identified and incorporated into the project planning and construction.

Even with full mitigation, residual impacts are impossible to avoid. Some are:

1. Visual impacts;

2. Interference and disruption of farming practices;

3. Lowered productivity; and

4. The very presence of a right-of-way may attract other systems seeking to make use of existing communications and access roads.

3. Operation and Maintenance

Highways and railroads occupy the entire right-of-way with tracks or pavement plus areas set aside for safety and reliable operations. Major highways and railroads normally fence along the right-of-way edge to prevent movement of animals and vehicles from interfering with traffic flow. Although this unavoidably interrupts wildlife migration patterns, it can be mitigated somewhat by underpasses, overpasses, etc.

Pipeline, electric transmission, and communication systems do not normally fence right-of-way boundaries, hence disturbance of migration routes is minimal. There is, however, an important environmental impact from these systems. The roads along or to various points on the right-of-way increase public access, particularly vehicle access, to previously inaccessible areas. Such accessibility has had an important impact on the natural and cultural resources, wildlife in particular. Erosion and littering problems are also compounded. Voluntary compliance goes only so far in mitigating these problems; active controls are often needed. Such controls include posting the land, barricades across roads, and patrols.

Related to the above problems, the impact of right-of-way use may conflict with social expectations for public land management. There is a direct conflict between utility and transportation systems right-of-way use and management for remote, wild, pristine, or open space values.

IX. ASSESSMENT OF CORRIDOR CONCEPT

A. Basic Corridor Requirements

1. Location

The selection of planning corridor locations requires the application of land-use planning principles, including development of an adequate data base to fully assess resource and environmental values of an area. It must confront the problem of determining which area will suffer the least environmental impact and at the same time provide an area through which all anticipated systems can be routed.

Location criteria for the individual system rights-of-way were discussed in Chapter VII. A suitable location for joint use of rights-of-way must obviously meet minimum requirements for each proposed system. However, caution should be exercised in designating all or a portion of an existing system for joint use since not all existing facilities are in a suitable location. Joint use represents, at best, a compromise location which would normally not be the route selected for any one transportation or utility system. It is, however, a location that all concerned parties have agreed they can tolerate without undue economic hardship or physical inconvenience to any of them.

2. Size

A planning corridor must be wide enough to allow alternate facility locations within its boundaries, seldom will it be less than 2 miles wide. The width must be variable and flexible, so no upper limit should be arbitrarily established. Instead, it should be based on the width of areas offering the least environmental impact and yet most suitable for transportation and utility right-of-way locations. Ideally, the length of a planning corridor would be sufficient to include all projected needs, but for the purpose of this study, emphasis is placed only on those portions that cross Federal lands.

The width of a joint-use corridor is considered to be in the general range of 500 feet to 1 mile, depending on the number and kinds of systems involved. The maximum width would be no more than that which would allow all systems to function with near zero interference between systems.

a. Construction, Operation, and Maintenance

Specific size requirements for joint use primarily vary according to the number and kinds of systems included. The larger the system and the more systems involved, the more complex their requirements become. Consequently, it is impractical to attempt to specify a set of requirements for joint use due to the variety of factors involved. It is equally as impractical to attempt to set, in advance, requirements for each of the various specific situations.

Transportation and utility industries have developed standards for determining the space needed to construct, operate, and maintain their facilities. Usually, each system is installed with minimum interference between and within systems which is achieved by space allocation. Some systems, such as pipelines, require considerably more area (about 50 percent more) during the construction phase than during the operation and maintenance phases. Although it is feasible to reduce the right-of-way width after construction, whether it is done or not depends on the type of right-of-way acquisition. Other systems, such as highways and railroads, retain the entire right-of-way for operation and maintenance. In such cases, land area requirements are dictated by the actual physical facility requirements, in addition to an adjacent control zone.

Under the joint-use concept, the sharing systems are located in close proximity to each other. This sometimes allows the combined space requirement of the systems to be less than the sum of the requirements for individual right-of-way installations. This is because, under optimum system configuration and sequence of construction, it may be possible to jointly utilize a common construction area and share the right-of-way fringe area. This procedure would cause the industries to modify some of their present philosophies and practices which discourage joint use. For certain interests, such as highways, this may be difficult. For years, highway regulations have contained provisions to allow nonhighway uses within the rights-of-way of interstate highways, but the other systems have had little success in making use of the highway right-of-way.

In addition to the area needed for the immediate construction, operation, and maintenance of each system in a joint-use right-of-way, space should also be reserved for growth and expansion of the systems.

b. Safety and Reliability

Safety and reliability are prime considerations in the operation and design of each system. For individual rights-of-way, the systems are spaced at an adequate distance to maximize these qualities. Each company having facilities in joint use must have assurance that the functions of one system will not threaten the safe operation and reliability of other parallel systems.

One of the most important factors related to both safety and reliability is the configuration of the systems in joint use. They must be arranged so that they will have the least adverse effect on each other and yet occupy a minimum amount of land.

The sequence of installation has a bearing on safety. For example, special measures are required when installing a pipeline next to an electric transmission system due to the induced voltage on a pipe isolated from the ground and the subsequent shock hazard. During the operational phase, adequate mitigation can be provided to eliminate the attendant shock hazard and corrosion problems.

Two transmission lines in separate rights-of-way exhibit higher reliability than in joint use. Two or more circuits in close proximity increase the probability of a single incident removing more than one circuit from service. Multiple-line outages can occur when damage to one line affects others due to a broken conductor contacting other lines, towers falling into other lines, or lightning flashovers to other circuits. System design and planning require careful consideration of such factors to prevent widespread outages or cascading situations.

There are no particular technical factors indicating that safety and reliability is degraded below acceptable levels by joint use, providing that preplanning and system design is adequate.

B. Technical Compatibility

Planning corridors rely specifically on land-use planning in order to minimize the resource and environmental losses which may result from proposed rights-of-way, and to assure suitable areas for their location. The technical compatibility aspects of the planning phase relate only to the basic considerations of specific planning corridor usage; originations and destinations; land requirements; grade, soil, and terrain considerations; and barriers and restrictions that must be avoided. Technical compatibility of the different systems involved relates specifically to locating systems in close proximity. The technical compatibility of systems in joint use of rights-of-way is discussed in the following paragraphs.

The width needed for joint use is determined by the engineering requirements of the systems involved, the degree of compatibility between and among systems, and the level of mitigation considered practical.

There are no formidable technical barriers to placing all five transportation and utility systems into a joint-use corridor if the topography is appropriate and the dielectric properties of the soil are acceptable. If the distance between systems decreases and length and/or electric transmission voltage levels increase, the degree of incompatibility increases, as do mitigation costs, along with reduced reliability and safety. At some point, the maximum level of mitigation costs and minimum level of reliability and safety are reached, thus establishing the minimum spacing feasible. The greatest impact would be associated with techniques to mitigate the electric transmission system's influence on other systems. Because of the variables involved, no single standard for separation can be established.

The configurations or arrangements of systems in joint use have a bearing on the right-of-way width required because of the interactions between the various systems. Figure IX-1, "Systems Interaction in Joint Use of Rights-of-Way," presents a summary of the interactions between the five systems. In this evaluation, it was assumed that most of the areas in which joint use would be established involve remote, rural land. Such locations would not require a substantial amount of system support facilities, such as railroad switching yards, highway interchanges, frontage roads, and power substations. If such facilities were necessary, they would be on an isolated basis and would require additional land areas.

Electric transmission systems represent the greatest obstacle to joint right-of-way usage with other systems due to the effects of powerline switching surges, fault currents, and electromagnetic and electrostatic fields. If mitigation measures and adequate separation are not maintained, these effects can cause corrosion of buried metallic structures, such as pipelines or coaxial cable sheaths, dielectric breakdown of buried cables, rupture of buried pipelines, failure of protection circuitry for buried cables, hazards to personnel, and malfunctioning of electric control of railroad signaling circuits and communication lines. Also, there can be interference to voice communication circuitry and radio and television reception, as well as audible noise. The usual means of solving the above problems has been to employ adequate separation. In cases where such separations cannot be maintained, mitigation measures such as shielding, undergrounding, and in some cases, changing the mode of system operation are employed on the affected utility system. Other mitigative techniques are installation of cathodic protection for corrosion control, lightning arresters, gas tube and carbon block protectors, and improved grounding.

The mitigation measures required on the electric system, and normally included in the design of the transmission line, are transpositions, increased aboveground clearance, bundle conductors, counterpoise, and harmonic filtering.

FIGURE IX-1

SYSTEMS INTERACTIONS IN JOINT USE OF RIGHTS-OF-WAY

Influencing System \ Affected Systems	Electrical Transmission	Communications	Pipelines	Railroads	Highways
Electrical Transmission	Reliability degraded . Safety during maintenance from voltage gradient.	Steady state noise. Fault & lightning damage. Shock hazard. Corrosion of cable sheath. Construction damage.	Corrosion. Shock hazard. Fire/explosion hazard. Construction damage.	Shock hazard. False control signals. Fire hazard. Communications interference.	Radio noise. Audible noise. Fire hazard. Shock hazard.
Communications	Faults during construction.	Crosstalk. Cathodic protection interaction. Construction damage.	Cathodic protection interaction. Construction damage.	Construction damage.	Access interference.
Pipelines	Faults during construction. Fire/explosion hazard.	Cathodic protection interaction. Fuel leak damage/personnel safety. Construction damage.	Cathodic protection interaction. Fuel leak/fire and explosion hazard.	Construction damage. Fire/explosion hazard.	Access interference. Fire/explosion safety hazard.
Railroads	Derailment caused outage - reliability degraded.	Electrified RR's same problem as power. Derailment damage to repeater stations or above ground facilities.	Electrified RR's same problem as power. Derailment damage to valves, compressor or pumping stations, etc.	Reliability degraded due to possible accident. Safety degraded.	Safety degraded due to potential accidents. Access interference.
Highways	Reliability degraded due to accident related outages.	Damage to repeater station or above ground facilities due to vehicle accident.	Vehicle damage to above ground facilities due to accident.	Reliability degraded due to possible accident. Safety degraded	Safety degraded due to potential accidents. Access interference.

SOURCE: The Aerospace Corporation, 1975

This study included detailed assessment of the compatibility problems associated with electric transmission lines in joint use with the other four systems. The exercise consisted of assuming several joint-use options and examining the relationships among the variables affecting compatibility, mitigating measures, and costs. Because of the technical nature of the subject, the assessment is described in the appendix rather than the main text. In assessing technical compatibility, it became evident that, while generalized observations can be made regarding compatibility factors, the complexity of the subject requires a specific project analysis before a joint-use decision involving electric transmission lines can logically be made.

C. Land Commitment

The acreage devoted to rights-of-way may be less in a joint-use situation than with separate routings, or it may be more, depending on the configuration and the systems involved. The relationship between required right-of-way acreages for pairs of systems in parallel and for the same systems on separate routes is shown in Table IX-1. The acreages in this table are based on normal requirements for single systems using present day practices, and minimum separations involving some mitigation and construction coordination. (Figures IV-3 and IV-4).

The following general observations can be made regarding Table IX-1: (1) When an electric transmission line is paired with another system, there is usually a greater right-of-way requirement than if the two systems are routed separately. These additional widths are needed to prevent severe incompatibility problems requiring extensive mitigation. (2) Pairs of systems not including transmission lines will generally result in a right-of-way land savings for the joint-use section. (3) Joint-use rights-of-way which include railroads indicate the greatest possible right-of-way savings. This is because the study was unable to substantiate the need for a continuous 200-foot railroad right-of-way, based on technical compatibility factors. Therefore, under these assumptions, only 100 feet are allotted to railroads.

TABLE IX-I

RIGHT-OF-WAY COMMITMENT - ACRES PER MILE

SYSTEM PAIRS	SEPARATE	JOINT USE
Transmission Line and Highway	48	55
Transmission Line and Pipeline	38	47
Transmission Line and Comm. Line	36	43
Transmission Line and Railroad	48	45
Pipeline and Communication Line	26	24
Pipeline and Highway	38	35
Highway and Communication Line	36	31
Railroad and Pipeline	38	31
Railroad and Communication Line	36	22
Railroad and Highway	48	33

Notes:

1. Transmission Line - 500 KV, single circuit
   Highway - 4 lane primary
   Pipeline - Two lines, 24" and 42"
   Communication Line - Two buried coaxial cables
   Railroad - Two mainline tracks

2. Right-of-way requirements are extremely variable. The above acreages are based on the configurations shown on Figures IV-3 and IV-4.

Although a savings in land required for rights-of-way could be realized by joining certain systems in parallel, this savings would be quickly negated if additional length were required for systems to join and follow a corridor. As an example, assume an alternate pipeline route would follow a highway for 50 miles. The amount of new right-of-way would be 150 acres less than that required for separate routings. However, 150 acres represents less than 11 miles of pipeline right-of-way. Therefore, in comparing alternatives, a total land savings would be realized only if the pipeline termini were near the highway and the increase in length is less than 11 miles. However, type and quality of land area in question may be of more importance than numerical length in miles.

D. Environmental Impacts

The planning corridor concept is beneficial from an environmental impact viewpoint because, in the process of establishing planning corridors, critical resources and potential impacts are identified. However, the land manager is still faced with the decision of whether joint use or separate rights-of-way are best for each individual situation.

The environmental impact of joint-use versus separate rights-of-way is difficult to assess. Depending on a number of variables such as terrain, number and types of systems included in the corridor, existing and future land use, etc., joint use may be either good or bad from an environmental standpoint. The question of whether the routing of linear systems should be deviated from their otherwise best location in order to join an established corridor cannot be answered without a complete environmental analysis in which all variable factors are known and considered.

Some environmental benefits of joint use are:

1. Shared access - Highways provide their own access. Railroads prefer vehicular access within their rights-of-way, and the other three systems depend on access roads for construction and maintenance of their facilities. In many instances access roads have a greater impact than the facility itself, particularly in rugged terrain where considerable road excavation is required. Because some facilities in joint use can often share the same basic road system, they can minimize the total visual impact, land-use disruption, and soil disturbance caused by access roads.

2. Visual impact - In certain circumstances, the overall visual effect of joint-use rights-of-way would be less than the total impact of separate routes. This situation would occur for example, in timber land where a pipeline or communication line could share the same cleared right-of-way with a powerline with little added visual impact.

3. Recreation - Although not necessarily applicable to Federal lands, a common joint-use area several hundred feet wide can provide recreational opportunities. In urban and suburban residential areas, the "green belt" formed by such an area can be managed for recreational purposes with parks, playgrounds, picnic areas, bike trails, etc. Conversely, separate rights-of-way through these areas may be too narrow for this type of use.

Undesirable environmental factors which must be considered in assessing joint use include:

1. Visual impact - Although visual impact was mentioned as a positive aspect of joint use, it may also have negative consequences. A single system can often be carefully located through an area with a minimum adverse effect on aesthetics, while the addition of one or more parallel facilities could increase the visual impact. Previously acceptable joint-use rights-of-way can easily become "overloaded," from a visual standpoint, by adding facilities. Numerous examples exist in mountain passes and narrow valleys, where several facilities have been forced together because of terrain constraints. These cluttered, overloaded rights-of-way which evolved out of necessity are considered by some as a visual affront.

In most remote settings, close parallels between transmission lines and highways are recognized as aesthetically undesirable.

2. Disruption of Land-Use Practices - All five systems included in this study cause some disruption to existing land use. In the case of highways and railroads, this disruption is permanent throughout the right-of-way width since previous uses are excluded. Pipelines, powerlines; and communication lines disrupt the land during the construction period, then the prior uses can usually be resumed. (An exception would be commercial timber production).

The combined impact on land use can be greater in a joint-use situation than the sum of individual impacts. For example:

- Access required for utility maintenance may be complicated by the fact that facilities can be reached from one side only, requiring circuitous road routings.

- In agricultural land, where aerial crop spraying is utilized, a single transmission line presents little problem, while multiple lines make adequate spray coverage more difficult.

- A single transmission line can be located between the circular irrigation patterns which are becoming quite common in the West. Parallel transmission lines cannot.

- Because of engineering factors, complete parallelism is generally not possible for great distances, even between similar systems. Consequently, isolated areas are left between adjacent facilities which are often too small for economic management, resulting in wasted land resources.

3. Unnecessary consumption of resources - Required joint use may result in additional length for one or more systems if they are to parallel in their entirety. The increased land committed to rights-of-way was discussed earlier. The commitment of nonrenewable resources which could otherwise be avoided is also an environmental consideration which must be recognized. The amount can be significant: For example, each mile of a 500 KV single circuit transmission line requires 60-100 tons of steel and 20-40 tons of aluminum, depending upon design parameters.

E. Economic Implications

Joint use of rights-of-way and the establishment of a system of corridors have certain economic implications felt mostly by industry, landowners, and consumers. The examination of each of these factions is general because of the limited data available and the complexity of the matter. This examination compares advantages and disadvantages, yet whether any item is actually an advantage or disadvantage is almost entirely a subjective matter. Still, this comparison will help identify relationships and present mechanisms for trading off positive and negative qualities.

1. The Industry

For the purposes of this discussion, it is the "industry" which seeks rights-of-way. The nature of the economic implications involved for each industry is basically similar, even though the specifics and scale of the impacts may vary.

a. Planning

The establishment of planning corridors may shorten the industry planning process due to the reduced range of alternatives which would have to be examined, in addition to the potential for joint planning between companies.

A further benefit from planning is its relative farsightedness. This enables anticipation of future problems which might be alleviated in the near future to reduce the potential for greater problems in the distant future. By anticipating demands and by knowing the expected growth of other systems, each industry is able to prepare itself for future situations in advance, thereby reducing the potential for crises and avoiding probable economic difficulties.

Such planning requires considerable coordination and cooperation among companies and public agencies. However, coordination can reach a point where the advantages of such are offset by the disadvantages. For example, as the total cost of planning decreases, the costs associated with coordination and cooperation can be expected to increase. The key to this rests with the varying goals and objectives intrinsic to each system. While the systems may not necessarily be competing, each will naturally seek to operate in its most efficient fashion. Certainly, companies will have to be prepared to compromise -- if such compromises are in the public interest. "Public interest" is considered to be an "appropriate" balance between the company's interests which relate to the direct needs of its customers and stockholders and the environmental interests which relate to the less direct needs of the public at large. When a company determines that to compromise would be contrary to its own peculiar definition of "the public interest," coordination and cooperation could become unreasonably costly, if not impossible.

A further potential disadvantage of open planning by industry is created by land speculators. In anticipation of the construction of transportation and/or utility systems, speculators may invest in lands and inflate their value. Then, the increased cost per acre could offset much of the savings resulting from the planning process.

b. Environmental Analyses

Joint use could present industry with marked savings in time and money spent in the preparation of environmental analyses, assessments, and statements. Utilizing separate rights-of-way, each company is required to conduct an extensive environmental analysis of the entire land area impacted by the proposed project. With joint use, each company could potentially take advantage of previous analyses of the route or combine their efforts. Accordingly, the companies could perhaps better evaluate the expected impacts on the region. This would result in more effective and responsible environmental assessments and statements and could be an important cost savings to everyone involved.

Nevertheless, this possibility is not without its difficulties, the major one being the allocation of the costs associated with preparing the initial environmental analysis.

Again, the success of sharing the costs associated with environmental analyses is dependent upon the coordination and cooperation of all companies and agencies involved. Without such cooperation, little savings will be gained.

c. Construction

Differences in construction costs associated with joint use as compared with separate rights-of-way may be viewed as having three major components:

(1) Length, in terms of the additional length required by the system to follow joint-use rights-of-way rather than a separate right-of-way;

(2) Mitigation costs, in terms of those additional costs required for two or more systems to be in proximity to each other; and

(3) Access costs, in terms of the savings realized by locating near an existing system rather than locating an entirely new route.

These three components together could significantly change the total cost of constructing a specific system. Additional length will increase total cost while not necessarily influencing the average cost per mile. On the other hand, the mitigation costs could greatly increase both the total cost and the costs per mile. Finally, the case of access for subsequent rights-of-way in close proximity could partially offset the cost increases attributed to length and mitigation.

Generally, construction costs are directly related to distance. Many companies are financially unable to consider any alternative which would raise their costs substantially. In joint-use situations, each company must absorb any mitigation costs. Depending on the increase in distance and possible mitigation costs, the construction of systems in close proximity could cost 50 percent more than the cost of the shortest distance. In some situations, this would render badly needed facilities economically unfeasible.

In remote areas where access is difficult, systems that locate adjacent to an existing facility may realize certain savings by utilizing existing access rather than constructing an entirely new road system. This, however, could be a disincentive to be the first system built unless there was compensation for initial work that benefited other companies. This, then, becomes another aspect of the coordination and cooperation problem.

d. Operation and Maintenance

There is no readily available information on operation and maintenance cost associated with joint use. It is anticipated, however, that there could be definite benefits in terms of shared access for maintenance.

Without this aspect, it would be difficult, if not impossible, to find significant benefits to industry in joint use of rights-of-way. As with every other aspect, the realization of these savings is dependent upon the coordination and cooperation of the participating companies and agencies.

2. The Landowners

The people most directly impacted by any decision with respect to rights-of-way are the landowners, Federal, State, and private. The major concerns to each of these landowners include the amount of land to be occupied, the location, type of use, type of land, and the restrictions or limitations required by the transportation or utility systems. These concerns may be translated into at least three major economic considerations: land management, productivity, and compensation.

a. Land Management

The Department of the Interior is charged with the responsibility for managing the majority of the Nation's public lands. The emphasis of this charge is placed upon conserving the Nation's land resources.

From a public land management view, it is preferable to collect similar activities into concentrated areas. It is anathema to the good manager to have his land laced with utility and transportation systems which segment the land and disrupt management practices. Among the basic land-management arguments against separate rights-of-way are the following:

(1) More land is consumed for rights-of-way than is necessary;

(2) The land commitment is irreversible and the impact will increase over time;

(3) The installation of the systems will unavoidably destroy natural resources;

(4) The rights-of-way will provide access to many hitherto inaccessible regions which would otherwise remain closed; and

(5) The rights-of-way will interfere with sound management practices.

To the extent that these arguments are true, the separate rights-of-way have an adverse economic impact on land management, but it does not appear that joint use is a significant improvement for the land managers. Each of the first four arguments above applies equally well to joint-use situations. The amount of land consumed by joint use may vary widely according to the particular circumstances. The land commitment in joint use is even more irreversible than with separate rights-of-way because there is a greater possibility of right-of-way abandonment with separate rights-of-way and the land returning to its prior use.

The fifth argument may, in fact, be stronger against joint use. Joint use represents a concentration of activity which would preclude many other activities within these rights-of-way. On the other hand, in the more dispersed arrangement, the magnitude of the impact is much less and the land could, in many instances, be maintained in very nearly its natural condition.

b. Productivity

A major economic impact, particularly on private agricultural lands, is the potential reduction in productivity. The specific nature of the impact varies with the type of system and the type of agricultural activity. For example, transmission lines, communications systems and pipelines will have minimal impact on rangelands after the initial disruption during construction. However, railroads and highways would present a significant disruption. If it is supposed that irrigated agricultural land is being traversed, all the systems could pose a significant impact on productivity by removing varying amounts of land from productive use.

Separate rights-of-way impact numerous private landowners to varying degrees. In some cases, they lose virtually all their productive capacity, while others suffer little or no loss. Joint use, on the other hand, would probably impact fewer landowners because of the concentration and proximity of the systems. However, those affected would likely suffer greater losses because more land might be taken and its use restricted to a much greater extent.

c. Compensation

To help offset the losses in manageability and productivity, industry is required to provide compensation to the landowner. This compensation may be in several forms depending on the particular set of circumstances. Common practice is for industry to acquire an easement and pay a fee for the use of land. Sometimes a company may decide to purchase in fee the land it requires. In any case, industry generally compensates the landowner at the current fair market value for his property. However, if his particular operation is only marginal, the right-of-way impacts could leave him with an uneconomical operation and force him to move. The probability of this type of situation occurring is increased with joint use because of the substantial amount of land required.

3. The Consumers

Ultimately, all the benefits and costs associated with rights-of-way, regardless of configuration, are passed on to the consumer. The consumer depends upon the transportation and utility systems to deliver necessary goods and services as well as to provide unrestricted opportunities for mobility. The consumer pays for these systems through the rates charged by industry and the taxes collected by Government. This discussion generally examines joint use, relative to separate rights-of-way, as it relates to product delivery, rates, and taxes.

a. Product Delivery

As indicated previously, industry is generally required to deliver, to the best of its ability, the products demanded. If industry is capriciously impeded in this effort, the adverse consequences could be significant. For example, should an electric utility company be detained from installing a necessary system until the existing system is overloaded, it could require emergency measures to provide the needed energy regardless of the "total" costs. Thus, in this situation, it might have been better to compromise in order to install the system in an orderly manner, rather than have the system installed in emergency circumstances.

With separate rights-of-way, the product has generally been delivered. However, there have been delays as a result of several factors, most notable inadequate environmental analyses, rising capital costs, inclement weather, and bureaucratic entanglement. With joint use, some of these factors might be alleviated. The problems of inadequate environmental analyses and bureaucratic entanglement, together, should be reduced since fewer areas will require examination as a result of right-of-way sharing. But, if the joint-use right-of-way is less than optimal in the view of the company, there are apt to be additional delays as a result of:

- Attempting to obtain approval for construction outside of the joint-use right-of-way;
- Engaging in possible litigation; and
- In the event of failure to be exempt from the joint-use right-of-way, requiring additional construction over a greater distance and investment in special mitigation techniques.

b. Rates

All costs to the companies are passed on to the customers in the rates they pay for the product. The construction cost does not necessarily imply that the same increase can be expected in the rates. For illustrative purposes only, the electric utility industry is examined here in a simplified fashion.

If it is assumed that the rates reflect the cost of service, then the revenue requirement for an electric utility should equal the sum of the operating expenses, the depreciation expenses, the taxes, and the return amount. In 1973, according to the Edison Electric Institute, the operating expenses (including depreciation and taxes) for all investor-owned electric utilities were approximately $21.1 billion. At the same time, the gross value of the property serving the public, less accrued depreciation, was nearly $124.8 billion. Of that $124.8 billion, roughly $14.9 billion was for new construction, of which $2 billion was for transmission. Thus, in 1973, only 1.6 percent of the rate base consisted of transmission construction. And, in this case, it follows that a 20 percent increase in total construction costs associated with transmission would increase the rate base by approximately 0.3 percent. (However, this amounts to $400 million in annual customer charges, which must be balanced by an equal value in environmental benefits to society resulting from joint use.)

Although this example is over-simplified and very general, it does provide an indication of the magnitude of impact on rates that might be expected if electric utilities were compelled to spend 20 percent more in a joint-use situation rather than to go the shortest distance on a separate right-of-way. The results can vary substantially depending on the size of the company, the extensiveness of the system, local construction costs, and the size of the service population.

Each system has a different formula for determining rates and fees--and these formulas tend to vary slightly from company to company. But, it appears evident from the data available, that increased costs due to joint use, while being passed on to the consumer, will not make a significant impact on the rates they pay. The impact is far greater to the companies having to bear the direct costs of additional length and mitigation.

F. Impacts on Intermingled Non-Federal Lands

It is impossible to assess the corridor concept on Federal lands without considering its effect on private ownership. Federal and private lands are often intermingled. Even if an entire proposed planning corridor is on Federal land, the designation of such a corridor would influence the location of facilities across private land if such facilities required to converge into a planning corridor. If planning corridors are to be established across Federal lands, they must be maintained very broad and flexible to avoid adversely affecting the rights of the private property owner.

Joint-use corridors have the potential for greater problems related to non-Federal land than do planning corridors. For example:

° The impact on individual and corporate land in the path of a preestablished joint-use right-of-way would be considerable. Therefore, condemnation may become an absolute necessity to maintain joint use, whereas a free choice of routing may avoid condemnation.

° When joint use is preestablished, public notice must be given of its location and planned use. Immediately, this will imply threat of condemnation on those parcels of privately owned land which fall within the borders of the joint-use area. Property owners may be able to collect damages through the courts long before joint use is actually in effect.

° The effect on small property owners in the path of a preestablished joint use corridor may be so drastic as to cause relocation of home, business, or both. Certainly these property owners would have to be reimbursed and relocated, but it is impossible to compensate for certain sentimental values.

° The residents of communities may view a designated joint-use corridor as a blight to the entire area and legal battles may ensue to prevent its existence. The same thing could happen if environmentally-oriented groups disagree with routing or see the wide swath of the joint-use right-of-way as being more objectionable than individual rights-of-way.

All of the above points bring out the fact that there would be a considerable amount of litigation associated with the preestablishment of joint-use corridors. The first user may be burdened with many legal battles and their associated costs, while subsequent users may have little problem with their projects. In addition, one user may have his project jeopardized because of objections to the facilities of one or more of the other users.

Apart from legal considerations, the idea of preestablishing a joint-use right-of-way without regard to its effects on private lands is unacceptable. The best location across Federal land will not necessarily result in the best route through intermingled and adjoining private ownerships. In order to site a facility in its most feasible location, engineering, environmental, and economic factors must be evaluated and weighed for the entire project, from beginning to end. The route chosen must be the most beneficial from an overall standpoint and may necessitate high impacts in some segments. If the Federal Government were to preestablish joint-use rights-of-way on Federal lands, these high impacts would most likely fall on private lands.

G. National Security

An analysis was made as to the vulnerability of joint-use rights-of-way to overt (wartime conditions) actions and covert (radical groups, sabotage, etc.) actions in comparison to the single isolated use right-of-way.

1. Overt Actions

It was found that joint-use areas are more vulnerable than single isolated use rights-of-way. A joint-use right-of-way could be "hardened," or made less vulnerable, by stipulating wide (6,000 ft.) corridors and/or by placing the more resistant systems such as communications and pipelines on the outside edges. However, even a hardened corridor would be more vulnerable to overt action than the same systems in dispersed rights-of-way.

2. Covert Actions

Joint-use rights-of-way present a preferential target in that they provide potential for a "bonus kill," the destruction of one system damaging or destroying another nearby. However, it is earier to physically prevent and combat penetration of joint use rights-of-way compared to single isolated rights-of-way because joint use concentrations are easier to physically patrol, fence, and monitor.

H. Other Considerations

The study identified several problem areas associated with joint-use rights-of-way which should be considered in any joint-use decision. Collectively they present an argument against preestablished joint-use corridors. They are not, however, factors in the assessment of planning corridors.

1. User Legal Control

Under present practices with each system usually solely occupying its own right-of-way, each is able legally to restrict and control all endangering activity within the limits of the right-of-way. In a case where portions of the right-of-way would be shared by more than one user, the problem of legal control is evident.

Legal control is considered necessary because of: (a) Financing constraints--investor-owned utilities must secure sufficient rights to certify complete control over their facilities in order to satisfy the requirements of lien holders or trust indenture; (b) Liability--utilities require indemnification by another user of the right-of-way for damage to facilities or third party injury related to use by the second utility.

2. Cost Sharing Between Users

If joint-use corridors should be preestablished, an equitable means of allocating right-of-way costs among users would have to be devised. It would be unfair for each user to share equally in the right-of-way acquisition and maintenance costs, because the right-of-way needs differ according to systems. Some sort of pro rata responsibility based on the amounts of right-of-way required by each user may be feasible. Where right-of-way requirements of adjoining users overlap, perhaps the shared-use area could be halved for financial and maintenance responsibilities. Where Federal land is involved the appropriate Federal agency could prorate right-of-way permit fees. Maintenance responsibilities could be fixed by joint use agreements between right-of-way users.

What about private lands? Could the Federal Government acquire the corridor and act as a landlord, redistributing the costs to all users on a pro rata basis? Such implications are far-reaching and unanswered and would require major policy decisions at a national level. Another option would be private ownership by one of the users, who would charge a rental fee to other users based on the area occupied and type and number of facilities accommodated.

Cost sharing for access road systems can be accomplished through a joint-use agreement similar to that often employed for main-haul timber access roads. Construction and maintenance funds are contributed by each user on the basis of expected usage, i.e., duration of use, frequency of use, size and type vehicle, etc.

Cost sharing issues do not appear to be insurmountable, but can be extremely complex.

3. Systems Expansion

In locating utility lines, it is common practice to provide space for future additional parallel facilities of the same kind. Even though no future lines are definitely planned at the time of the first location, the utility companies recognize the probability of future expansion - either by upgrading existing facilities or by parallel construction.

The electric utility industry, in particular, is experiencing such rapid growth that considerable rebuilding to higher voltages and parallel construction is expected.

The railroad industry, too, anticipates future expansion in the form of paralled roads for off-track machinery and transportation vehicles, but no extensive new track.

Parallel highways are unlikely. However, highways will undergo expected expansion by the addition of frontage roads, extra lanes, and interchanges.

Unfortunately, the location of multiple systems in a narrow joint-use right-of-way greatly restricts the opportunity for the future expansion of individual systems within it. This important factor will certainly be a major concern in the evaluation of minimum width, joint-use corridors.

4. Sequence of Entry

The sequence in which various systems are planned for construction is an important consideration in determining the feasibility of a specific joint-use right-of-way.

Transmission lines are particularly vulnerable to damage by nearby construction activities and also present a potential hazard to workers engaged in constructing adjacent facilities.

Railroads and controlled-acccess highways in use during construction of adjacent utilities restrict the movement of equipment and will normally increase construction costs. Conversely, stringent alignment and grade criteria for highways and railroads make it essential that these systems be designed and surveyed, including cut-and-fill staking, in order to locate a utility truly parallel. In other words, it would be unrealistic to expect a highway or railroad to parallel the alignment of an existing utility except for a straight line across flat ground. Ideally, the sequence would be for the highway and/or railroad to be designed and its construction limits marked on the ground. Then the pipeline and/or communication line would be located and built parallel. Next would be construction of the highway and/or railroad, and finally the transmission line. Obviously, this sort of planned, coordinated sequence of entry will rarely be possible.

APPENDIX - E

TECHNICAL COMPATIBILITY BETWEEN TRANSMISSION LINES AND OTHER SYSTEMS IN JOINT USE OF RIGHTS-OF-WAY

The following material is based largely on data extracted from a contract effort by The Aerospace Corporation. Aerospace was contracted to examine and assess the technical factors related to the joint use of rights-of-way. Since most compatibility problems involve the effects of electric transmission, a great deal of effort is concentrated on electrical interference to other systems. The following is a very basic treatment of a complex subject and is presented here only to give the reader a feel for the significance of the various problems encountered in joint use.

It must be stressed that the examples showing separations, mitigation measures, and costs only indicate what may be required. They are not intended as guidelines to be used in future situtations. The major finding of the technical compatibility evaluation which cannot be overemphasized is: the technical factors involved in joint use are so complex and variable that an evaluation of each individual project is required before any joint-use decision can be made.

1. Description of Compatibility Problem

a. Electrostatic and Electromagnetic Coupling

(1) Telephone and Railroad Communication Circuit Effects

Most alternating current powerlines in the United States have a fundamental frequency of 60 Hz, and the bulk of energy is transmitted at this frequency. This alternating voltage or current is not usually a pure 60 Hz sine-wave, but may contain harmonics of 60 Hz which go into a voice frequency range (180 to 5,000 Hz). High Voltage direct current systems, unless adequate filters are provided, can also cause noise in carrier type communication systems which operate above 5000 Hz. Harmonic currents and voltages present on powerlines can cause serious inductive interference problems to adjacent railroad signaling or wire communication circuits. These harmonics can be generated at HVDC systems or any industrial process where the pure 60 Hz wave form is distorted. If the harmonics are caused by utilization equipment at the load end of the power transmission system (such as aluminum plants and induction arc furnaces), harmonic currents can be fed back into the power system, allowing them to couple into the communication circuits. Adequate filtering within the power system can reduce these harmonics to acceptable levels, but in some situations the most economic solution is to take remedial action in the communication circuits.

The three basic factors of inductive coordination are: Inductive Influence, which is the combined effects of the characteristics of the wave form of the power being transmitted and the power transmission system design; Electric and Magnetic Coupling, which is the electrical interrelation of the power and communication circuits; and Susceptiveness of the communications system determined by the design characteristics of the communication circuits in relation to the extent which they can be adversely affected by the power system.

In addition to noise interference, potentially hazardous voltages and currents can be induced into parallel communication facilities unless they are mitigated by proper grounding, shielding, and safety precautions.

(2) Pipeline Effects

Inductive Coupling - The magnitude of the voltage induced in a pipeline is dependent upon the distance between the powerline and pipeline, the length of parallelism, the frequency of the current, the electrical loading of the transmission line, the magnitude of the zero-sequence current, the conductance of the pipeline coating, the size of the pipeline, the resistivity of the soil surrounding the pipeline, and the impedance of the pipeline itself. Sixty volts have been measured on a 50-mile parallel with a 230 KV line, while a 28-mile parallel with a 500 KV line in high resistivity soil produced 100 to 180 volts.

Capacitive Coupling - During construction, an above-ground pipeline may have a significant capacitive voltage induced on it. It is common practice to weld pipeline sections several miles long, along the side of the ditch, with the pipeline lying on skids or other high-resistive material supports. Fatalities have occurred to personnel approaching pipelines being constructed under these conditions, and grounding of the pipelines is imperative.

Corrosion - Corrosion caused by HVDC transmission lines is of considerable concern to the pipeline industry. However, the potential for DC corrosion arises primarily in the case of the DC system operating with earth return, rather than bipolar operation or monopolar metallic return operation. DC systems are normally designed for bipolar operation and the ground return is used only for short periods of time. During these periods the current flows out in all directions around the electrode and is distributed according to the mass resistance of the earth rather than along the DC line. Some current flows near the surface of the earth and may flow in and out of buried metallic structures. The problem is naturally more significant near the electrodes. By minimizing the periods of ground return operation and by proper design of ground electrodes and modification of pipeline cathodic protection systems, potential problems of corrosion from HVDC systems can be mitigated.

AC corrosion is known to exist, but only at about one percent the rate of DC.

Pipeline Communications - Well coated, insulated pipelines are sometimes used as a communications channel to telemeter data to pumping and compressor stations. Induced current can interfere with this use.

(3) Electrical Effects on People

Electrostatic fields from power transmission lines can induce voltage and currents in objects and people nearby. Spark discharges can occur when contact is made with objects under or adjacent to transmission lines. High values of the electrostatic field near the earth (ground gradient) can produce discomfort to people or animals walking or standing under transmission lines. Experience to date indicates that ground gradients can, under certain conditions at EHV and UHV levels, cause hair erection and a tingling sensation at contacts between body and clothes. The more serious effect is electrostatic voltage induced into ungrounded metal objects near EHV powerlines which can cause short circuit

currents through the body of persons contacting the object. This requires modified construction and maintenance procedures on all systems next to transmission lines.

A primary factor in evaluating the severity of an electric shock is the tolerance of the human body, which is measured in milliamperes of current flow. Table E-1 shows the effects of alternating current on humans.

TABLE E-1

EFFECTS OF ALTERNATING CURRENT ON HUMANS

EFFECT	CURRENT (mA)
SLIGHT SENSATION ON HAND	0.4
PERCEPTION THRESHOLD	1.1 1/
SHOCK - SAFE "LET-GO" VALUE	5 2/
SHOCK - NOT PAINFUL, MUSCULAR CONTROL NOT LOST	1.8
SHOCK - PAINFUL AND SEVERE MUSCULAR CONTRACTION, BREATHING DIFFICULT	23
SHOCK - POSSIBLE VENTRICULAR FIBRILLATION EFFECT FROM 3-SECOND SHOCKS	100

1/ Value for 180 pound person
2/ Estimated value for 99.5% of children (NESC, Proposed Seventh Edition)

SOURCE: National Safety Council Accident Prevention Manual for Industrial Operations, 6th Edition

The resistance of the human body is extremely variable, depending primarily on the wetness of the skin. The dry skin resistance from hand to foot can be as high as 600,000 ohms, while the lower limit for wet skin is about 1,000 ohms.

A maximum level of about 50 volts is often used as an objective for induced voltage to objects during normal power system operations. There is not a general agreement between and within the industries as to the maximum safe level. A body with 1,000-ohm resistance exposed to a 50-volt potential will receive 50 milliamperes of current flow - well beyond the safe "let-go" value. The latest information available indicates that 20 volts maximum is being considered as a standard.

b. Lightning and Fault Currents

(1) Lightning

Lightning can cause overvoltages in the form of surges on electric powerlines. A thundercloud is bipolar, with positive charges at the top and negative charges at the bottom. When the electric field strength exceeds the breakdown value, a lightning discharge is initiated, which proceeds to the earth. When close to the earth, a faster and luminous return stroke travels along the initial channel, and several such leaders and return strokes constitute a flash. The magnitude of the return stroke can be as high as 200,000 amperes, although an average value is on the order of 20,000 amperes.

When a stroke arrives on an overhead powerline conductor, equal current surges are propagated in both directions away from the point of impact. The magnitude of each surge is dependent upon the conductor surge impedance. For example, if the conductor surge impedance is 350 ohms and the current is 20,000 amperes, the voltage surge will be 3,500 KV or 3.5 MV.

Powerlines are sometimes protected by overhead ground wires to reduce the probability of flashovers during electrical storms. In addition, counterpoise is utilized under towers in high resistivity soils.

A lightning stroke usually causes a flashover of a phase wire due to ionization which causes a general fault current on one or more phases. Such faults can run from a few to 10's of 1,000's of amperes, and will persist until interrupted by circuit breaker action, usually on the order of 20 to 100 milliseconds. When the stroke arrives, it sets up surges flowing both directions along that wire and on reaching neighboring towers, the voltages are sufficient to arc across the insulators. The surges are propogated over the entire length of the line with partial reflections from each tower. Flashovers reduce, but do not eliminate, the surge intensity so that at most the nearest four or five towers will experience arc-over.

A fault in a power transmission system usually occurs by lightning and resultant flashover of the insulators. Ionization establishes a low resistance path across the insulators and a phase fault-to-groundd occurs. Seventy to eighty percent of transmission line faults occur in this fashion. Standard fault clearing times are from 2 to 8 cycles after the fault occurs, or 30 to 130 milliseconds.

(2) Pipeline Effects During Fault Conditions

When a sufficiently high electrical voltage is applied to the insulating coating around the pipeline, an arc can occur and remain at a local perforation of the insulation. This produces a large current at the defective point in the piping and can result in failure of the pipeline itself, and possible ignition of flammable contents. Thus, the voltage between the metal piping and the ground must be kept below those corresponding to arc formation. Tests under laboratory conditions with various voltage levels indicate that 5 KV applied for a period of 1 second will produce no metal erosion on typical pipelines; that 10 KV will produce some corrosion but no perforation after 1 second; and that 15 KV will perforate the piping in less than 1 second of voltage application. Thus, 5 KV can be taken as the maximum allowable potential stress to be applied to a pipeline. If this voltage level is exceeded, mitigation in the form of lightning arrestors or spark gap protectors, which will operate within the rapid rise of the fault or lightning current, can be installed to limit the maximum potential to the 5 KV or lower figure.

(3) Communications Effects During Fault Conditions

A problem similar to pipelines exists for buried cables, except that the limiting factor is related to power feed converter shutdown under the induced voltage occurring during fault conditions. For the long-line coax system this induced voltage limit is approximately 1.5 KV. Modern coax design provides a shield factor of .075, which means that 20,000 volts could be induced to the cable.

Protection for buried telecommunication lines utilizes a variety of techniques. Simple low-cost carbon-block protectors which have a limited current carrying capacity, gas-filled protector tubes, short-circuiting or grounding relays, isolating transformers, drainage transformers, diode protectors, use of special grounding and shielding techniques, and even fuses can be utilized to prevent equipment damage. The carbon-block protector is safe and dependable and will normally withstand a number of operations before becoming permanently short-circuited. However, a permanently short-circuited carbon block will ground the facility, interrupting service and causing excessive noise. For this reason, gas-filled protectors are preferred, even though their cost is roughly three times that of the conventional carbon-block protectors.

(4) Effects on Railroad Signaling Circuits During Fault Conditions

American railroad practice breaks both rails into blocks by means of insulating joints. A battery is then connected between the rails at one end of a block, and at the other end of the block a relay is connected between the rails to control the signal light beside the track. With the track normal and unoccupied, current flows from the battery through one rail, through the relay and back through the other rail, thus causing the relay to pick up and establish a circuit to light a green signal light. When a train enters the block, the rails are short-circuited by the wheels and axles, causing the relay to be deenergized and to drop open. This results in a red signal light indicating that the block is occupied. Should a rail break, thus interrupting the track circuit, the relay likewise drops open and initiates a red signal. Thus the system is fail-safe since failure of the battery to deliver current through the rails to the relay for any reason whatsoever initiates a red danger signal.

Fault-induced voltages could cause problems with track signaling and protective circuitry. Current-limiting protection for the track-control circuitry is required, with over-voltage protection required for the tracks themselves.

c. Electromagnetic Radiation

(1) Corona

Corona can be defined as an electrical discharge which occurs when the voltage applied to a conductor is greater than the dielectric of the surrounding insulation. Air at normal atmospheric pressure and temperature will break down at 30 KV/cm. This gradient is a function of the transmission conductor design, and is a function of conductor diameter, line configuration, type of conductor, condition of the surface, weather, and the voltage level. The discharge which occurs in the air surrounding the conductors subject to this stress is easily detected by a hissing sound, and at night by blue tufts or streamers surrounding the conductors. Corona discharge is amplified during foul weather conditions, and by irregularities on conductors and supporting hardware such as bugs, bird droppings, dust, dew, snow, water droplets, or burrs and nicks. The most effective way to reduce or avoid corona is the use of bundle conductors, i.e., two or more conductors per phase suspended from common insulators and separated mechanically by spacers of various designs. On some systems four conductor bundles are in use.

The configuration of conductors forming a bundle modifies the surface electric field so that the maximum stress is lower than with the single conductor. Also, the current rating of the circuit is increased. Troubles with bundle conductor lines have been experienced due to aerodynamic instability, resulting in mechanical oscillations along the line.

(2) Radio Interference

Electromagnetic radiations from the powerline produced by corona discharge generate interference in the radio frequency spectrum. The interference level generated by the line is a function of frequency, decreasing with increased frequency. Due to the receiving characteristics of an AM receiver, the greatest degradation of reception will occur in the AM band. Acceptable AM reception is based on a signal-to-noise ratio of 25 db. Fair weather AM radio interference levels are 15 to 25 db less that the interference levels during foul weather. A reduction of radio interference levels can be accomplished by an increase in the size of the bundle conductor, proper selection of subconductors and basic line hardware. Radio frequency interference in the FM broadcast band has not been significant.

The United States Federal Communications Commission at one time attempted to set an allowable limit on radiation from high voltage powerlines and had proposed 15 microvolts/meter in 1949. As a result of widespread industry protest, this limit was never adopted and presently there is no restriction on allowable radiation in the United States.

(3) Television Interference

Television Interference (TVI) has not proved to be a significant problem except in rural and fringe reception areas. Normally, a signal-to-noise ratio of 100:1 (40 db) is used as the criterion of adequate reception, and the principal area field controls specified by the FCC require 2510 u V/m of signal strength. The allowable TVI is thus 25 u V/m. The TVI is dependent on weather conditions and can range as high as 100 u V/m during heavy snow conditions. The 25 u V/m level is reached at 50 to 100 feet from a 500 KV line. The rural and fringe area field controls are 224 u V/m for rural and 51 u V/m for fringe areas. Thus the allowable TVI for these areas is 2 and .5 u V/m respectively. These levels may occur between 300 and 1,000 feet respectively, from a typical EHV powerline.

(4) Audible Noise

Audible noise emission results from the cumulative effect of crackling noises produced by corona streamers at the conductor surface. It is primarily a wet conductor phenomena, increasing sharply during rain or snow conditions. In wet conditions, water droplets collecting on the conductor surface create a large number of corona discharges, each causing a burst of noise. The audible noise emission depends upon the conductor surface condition, the precipitation on the conductor, and the wind velocity. The effects are primarily of a nuisance nature. People residing in areas near 500 KV powerlines have few or no complaints when the audible noise is kept below a sound pressure level of 52.5 db (A), and numerous complaints occur when the level gets above 58.5 db (A), where A is a weighted sound-pressure standard. The audible noise level at the right-of-way edge for a well designed multiple sub-conductor 500 KV line will be below an objectional level.

2. Mitigation Measures

a. Types of Mitigation

Power transmission line properties can cause severe problems to other utilities attempting to use the same right-of-way. The simplest mitigation measure has been the avoidance of the problem by keeping the powerlines 1/4 mile or more away from communication lines, pipelines, and railroads. In this fashion, there has been a minimum need for costly inductive mitigation to solve interference, corrosion, or hazard problems.

Since joint use of rights-of-way has been the exception rather than the rule, no generally consistent scheme of protection or mitigation has been developed. If, however, a joint-use right-of-way were planned, then the powerline, communication line, and other utilities could be jointly designed to minimize the impact of one or the other in a more cost effective approach. In the past, it has cost up to $45,000 per mile to mitigate powerline effects upon communication circuits, and these costs have usually resulted from relocation, burial, and shielding of high dielectric strength cables, as well as the provision of the proper cathodic protection circuitry. Similar costs have been incurred to protect railroad signal and communication lines, either by installing protective devices or by replacing with other type communication systems.

While the technology exists for providing joint right-of-way utilization for all utilities, the effects are felt in reduced reliability, increased safety problems, and greatly increased costs.

Where separation cannot be provided between the powerlines and the other utilities, the electromagnetic field could be reduced by improving the balance of the powerline phase currents and by providing powerline transpositions, coordinated with those of the telecommunications facility. Filtering should be installed to reduce any harmonics injected into the line. The effects of powerline electrostatic fields are best mitigated by undergrounding open wire signal and communication circuits and grounding the cable sheaths.

b. Need for Mitigation

Figure E-1 is of assistance in determining the mitigation required for long parallels of pipelines or buried cables with power transmission lines. These curves were generated by The Aerospace Corporation and are based on Carson's equations for mutual impedance between the powerline and the paralleling facility. This figure plots volts induced per mile of parallelism for a 10-ampere ground current, which represents a line unbalance of 5% for a nominal 2000-ampere power transmission line, reduced by a factor of 10 to account for leakage resistance.

As a check on the validity of using Figure E-1, there is a 28-mile parallel of a 36-inch high pressure buried gasline with a 500 KV powerline in northern California, at an average separation distance of 100 to 125 feet, with a maximum parallelism. The soil has ranged from 500 ohm-m to 2000 ohm-m. The steady-state induced voltage was as high as 100 to 180 volts, with an average of 25 to 50 volts over the length of the pipeline.

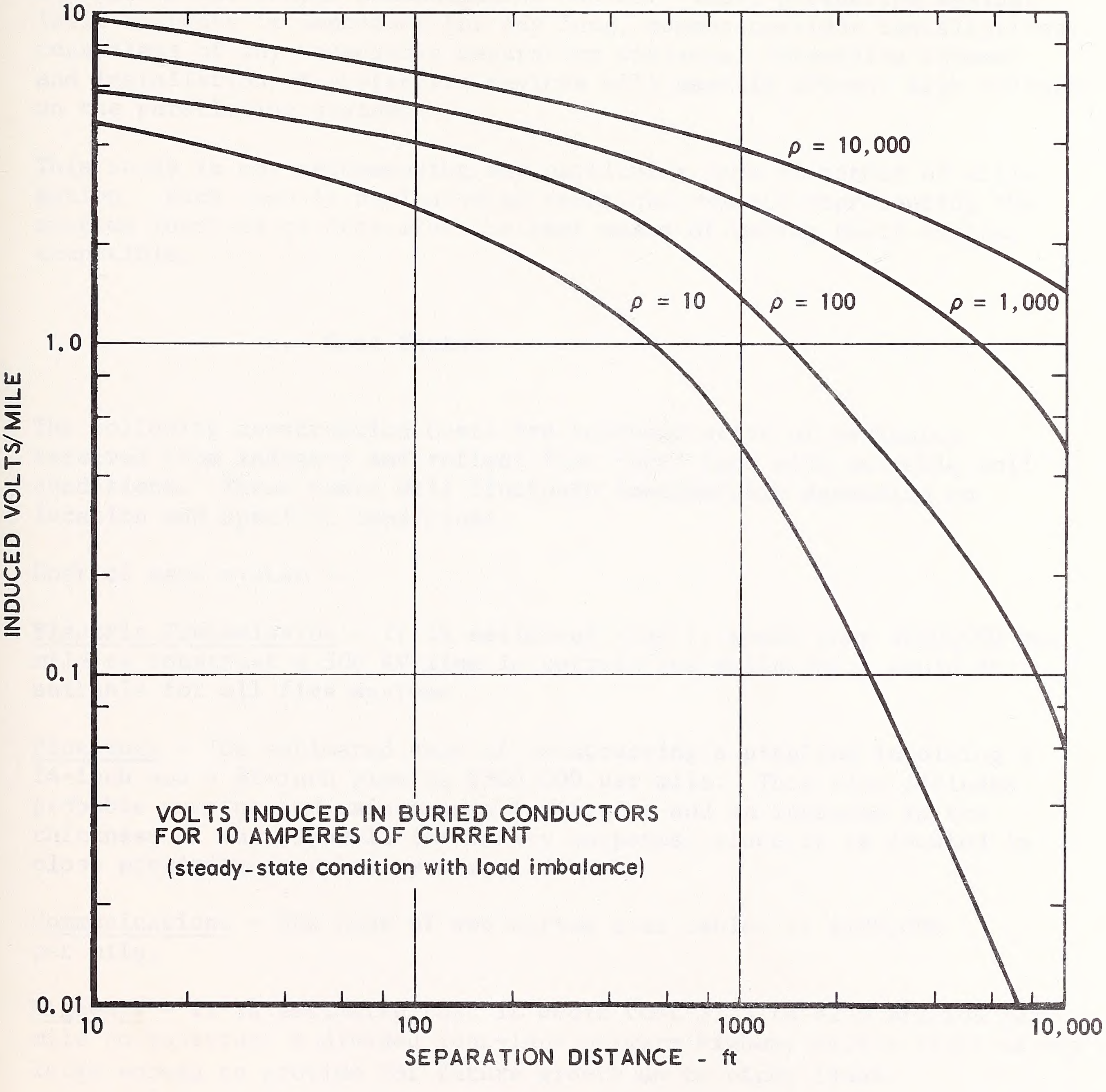
Using the 125-foot separation distance and the soil resistivity of 1,000 ohm-meters, gives an induced voltage of 5 volts per mile, which, for the 28-mile paralleled length, gives 140 volts. This is in close agreement with the measured data, and indicated that Figure E-1 can provide a good approximation of actual values when the soil restivity is known.

When joint use involves a hundred miles of parallelism, rather than one or ten miles, personnel safety limits for induced voltage are quickly reached at even wide separations. For a 100-mile parallel, a 50-volt limit is reached at a 1,000-foot separation for the most conductive soil, and several miles separation for the least conductive. Thus, for purely personnel safety reasons, mitigation must be provided to all pipelines and communication lines in joint use requiring long parallelism.

FIGURE E-1

INDUCED VOLTS PER MILE VERSUS SEPARATION DISTANCE

STEADY-STATE



SOURCE: The Aerospace Corporation, 1975

The most likely problems requiring mitigation involve fault currents. The curves in Figures E-2 and E-3 are examples of induced voltage that may be expected from typical fault currents; it should be remembered that faults can range up to 60,000 amperes in certain circumstances.

It is obvious from an inspection of this data that given a severe fault and a long parallel, exceedingly high voltages will be impressed across a buried metallic conductor. This voltage can be high enough to perforate a pipeline and damage communication cables. Thus, protection against fault currents is mandatory for any long, common-corridor installations, regardless of any reasonable separation distance. Grounding schemes and installation of protective devices will usually prevent high voltages on the paralleling systems.

This study is not recommending any particular type or method of mitigation. Each case is evaluated by technical experts representing the systems involved to determine the best means of making their systems compatible.

c. Cost Factors

The following construction costs are representative of estimates received from industry and reflect flat rural land with suitable soil conditions. These costs will fluctuate considerably depending on location and specific conditions.

Cost of each system --

Electric Transmission - It is estimated that it would cost $220,000 per mile to construct a 500 KV line in terrain and soils which would be suitable for all five systems.

Pipelines - The estimated cost of constructing a pipeline involving a 24-inch and a 42-inch pipe is $500,000 per mile. This also includes probable pumping and maintenance facilities and an increase in the thickness of the pipewall for safety purposes, since it is located in close proximity to other systems.

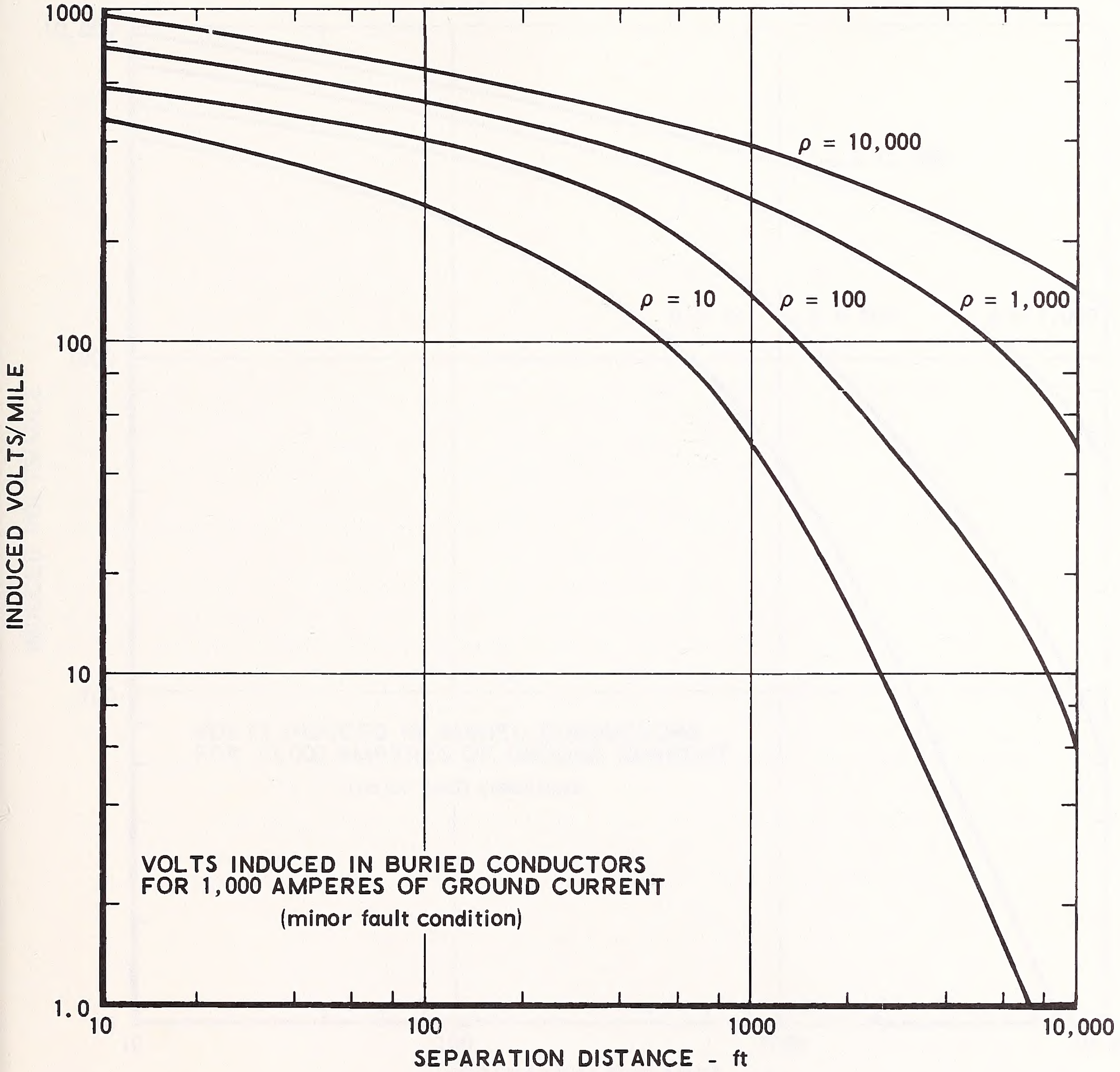
Communications - The cost of two buried coax cables is $300,000 per mile.

Highways - It is estimated that it would cost $1.5 to $2.0 million per mile to construct a divided four-lane primary highway with a right-of-way large enough to provide for future growth up to eight lanes.

FIGURE E-2

INDUCED VOLTS PER MILE VERSUS SEPARATION DISTANCE

MINOR FAULT

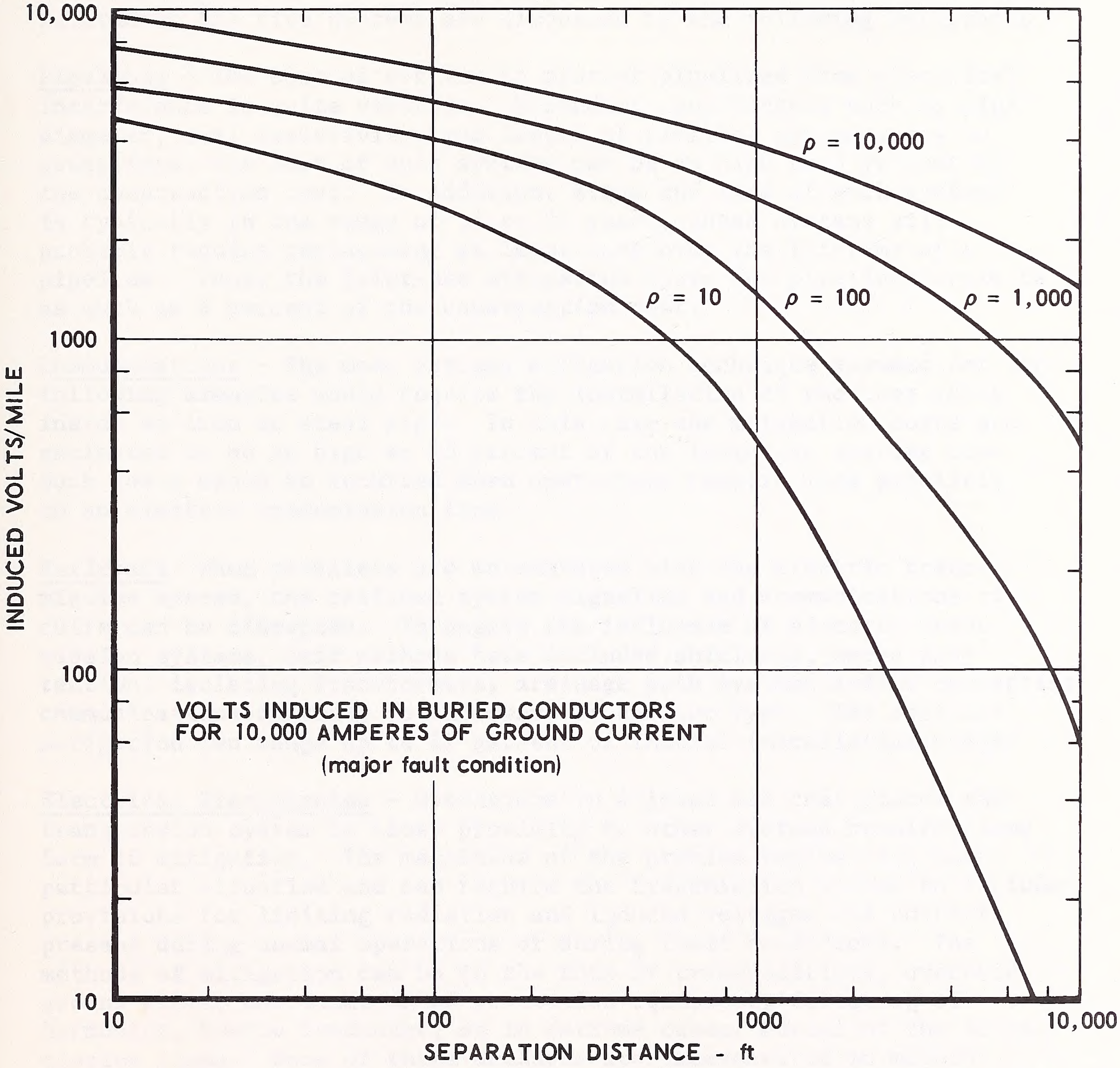


SOURCE: The Aerospace Corporation, 1975

FIGURE E-3

INDUCED VOLTS PER MILE VERSUS SEPARATION DISTANCE

MAJOR FAULT



SOURCE: The Aerospace Corporation, 1975

Railroads - It is estimated that it would cost $500,000 to $700,000 per mile to construct a single mainline with provisions for growth up to four tracks.

When systems are operating in close proximity, as would be experienced in the following evaluation, this may require affected systems to provide a means to mitigate the influence of the other system on its operation. In some cases the cost of the mitigation can be a significant portion of the initial installation cost. Some of the cost impacts related to the five systems are discussed in the following paragraphs.

Pipelines - The cost of systems to protect pipelines from electrical interference is quite variable. Dependent upon factors such as pipe diameter, soil resistivity, and length of parallel and nearness to powerlines, the cost of such systems can be as high as 3 percent of the construction cost. In addition, since the life of such systems is typically in the range of 15 to 25 years, these systems will probably require replacement at least once over the lifetime of a pipeline. Thus, the joint-use mitigation costs for pipelines could be as much as 6 percent of the construction cost.

Communications - The most extreme mitigation technique assumed for the following examples would require the installation of the coax cable inside an iron or steel pipe. In this case the mitigation costs are estimated to be as high as 45 percent of the installed systems cost. Such costs could be incurred when operations require long parallels to an electric transmission line.

Railroads When parallels are encountered with the electric transmission system, the railroad system signaling and communications circuits can be disrupted. To negate the influence of electric transmission systems, past methods have included shielding, surge protection, isolating transformers, drainage path systems and/or converting communications circuits to microwave or carrier type. The cost for mitigation can range up to 12 percent of initial installation costs.

Electrical Transmission - Operations in a joint use that places the transmission system in close proximity to other systems requires some form of mitigation. The magnitude of the problem varies with each particular situation and can require the transmission system to include provisions for limiting radiation and induced voltages and currents present during normal operations or during fault conditions. The methods of mitigation can be in the form of transpositions, overhead ground wires, coordination of protection equipment, filtering of harmonics, bundle conductor, or in extreme cases, burial of the transmission lines. Some of these measures are incorporated in modern transmission designs as standard practice. The associated costs with each approach varies greatly, ranging up to values, in case of the buried lines, as high as 10 to 20 times the installed cost of equivalent above-ground construction.

3. Evaluation

Based on the system requirements, compatibility factors, and methods and costs of mitigation, several joint-use options were defined and examined. Three key options for joint-use configurations are illustrated in this report. These options are:

I. A baseline right-of-way containing five systems requiring no special mitigation methods.

II. A right-of-way containing five systems, of reasonable width for construction purposes and reliable and safe operations but requiring significant mitigation.

III. A narrow right-of-way containing five systems, which degrades growth, requiring significant mitigation and some coordination of construction operations.

The rationale behind the systems arrangements was, in general, to minimize the interaction with the electrical transmission systems, the major source of corridor compatibility problems. Because of the number and complexity of the variables involved, it was necessary to make certain assumptions: type of systems, flat terrain, remote area, suitable soils, etc. Therefore the three corridors depicted are not considered typical or representative, but only examples to serve as a basis for general conclusions. In the graphic presentations, as many variables as possible were incorporated without rendering the drawings incomprehensible to most readers. Covered, for example, are various lengths of parallel (10, 50, and 100 miles), a wide range of soil resistivity, and both fault and steady-state conditions.

The following assumptions were used by The Aerospace Corporation in determining interference values and required separations.

1. All communications and signaling lines were buried, and if a metal sheath was utilized, that sheath has cathodic protection whether it is under powerline influence or not. Therefore, cathodic protection was not assumed to be a mitigative measure. Also, the sheath may be grounded at intervals along its length.

2. All pipelines were assumed to have cathodic protection whether under powerline influence or not.

3. 50 volts max. was used for personnel safety.

4. 5,000 volts max. was used as hazard to pipelines.

5. 2,500 volts max. was used as hazard to twisted pair type cables.

6. 1,500 volts max. was used for center conductors of coax cable.

7. 0.075 was used as shield factor for coax cables. 0.01 was used as shield factor for pipe when used as a cable shield.

8. In corridor applications, all buried conductors, including pipelines, were considered continuous over the length of the corridor with no insulated joints.

9. When a fault occurs, the ground current was assumed to flow over the complete corridor length (i.e., the generating station at one end and the fault point at the other end).

10. When a fault occurs, no other conductor was present to mitigate the effect of the ground current on a system.

11. A transmission line current flow of 2,000 amperes was assumed for the baseline system.

12. A 5% line imbalance was assumed for steady-state conditions, with a resultant ground current of 100 amperes.

13. Fault currents over the corridor length were assumed to be 10,000 amperes maximum.

14. Both steady-state and fault ground currents were reduced by a factor of 10 to account for leakage resistance in the paralleling facility. Hence, induced voltage curves for 10 amps steady-state and 1,000 amps fault ground currents were used in determining separations.

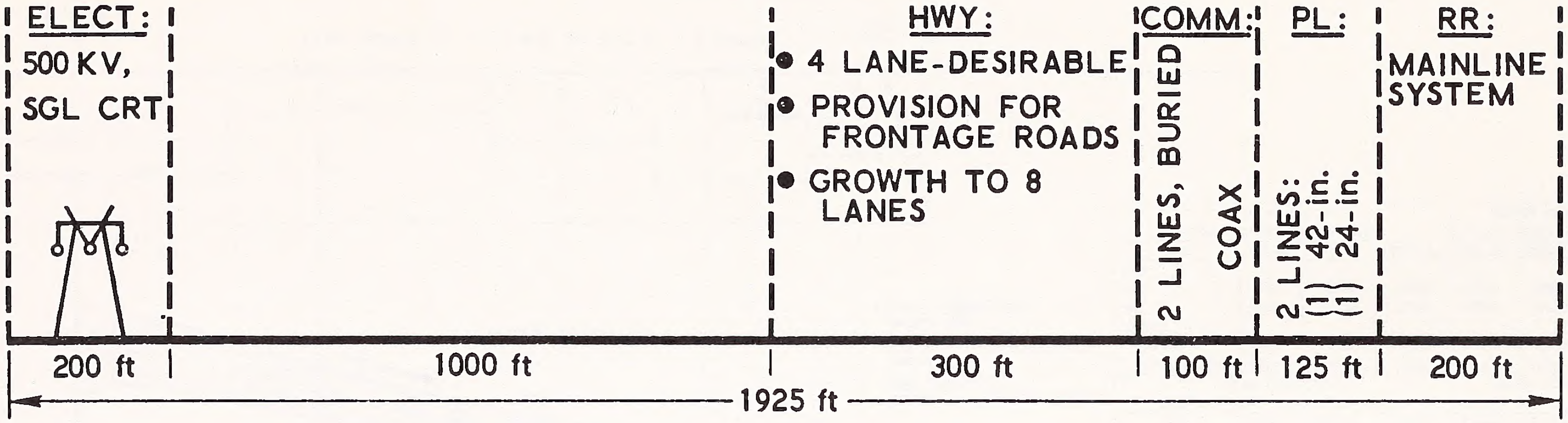
Option I is shown in Figure E-4. In this arrangement, the allocated right-of-way for each system should not result in any interference during construction or operation, and includes space for growth. Note that the required corridor width, to avoid mitigation, ranges from 1,925 feet to nearly 3 miles, depending on length of parallel and soil resistivity.

Option II - In the second option, indicated in Figure E-5, the objective was to analyze the compatibility factors for a corridor of reasonable width where construction flexibility, system operations, safety, and reliability are not impacted. A minimum of construction

FIGURE E-4

BASELINE JOINT-USE CORRIDOR - OPTION I

10 MI PARALLEL



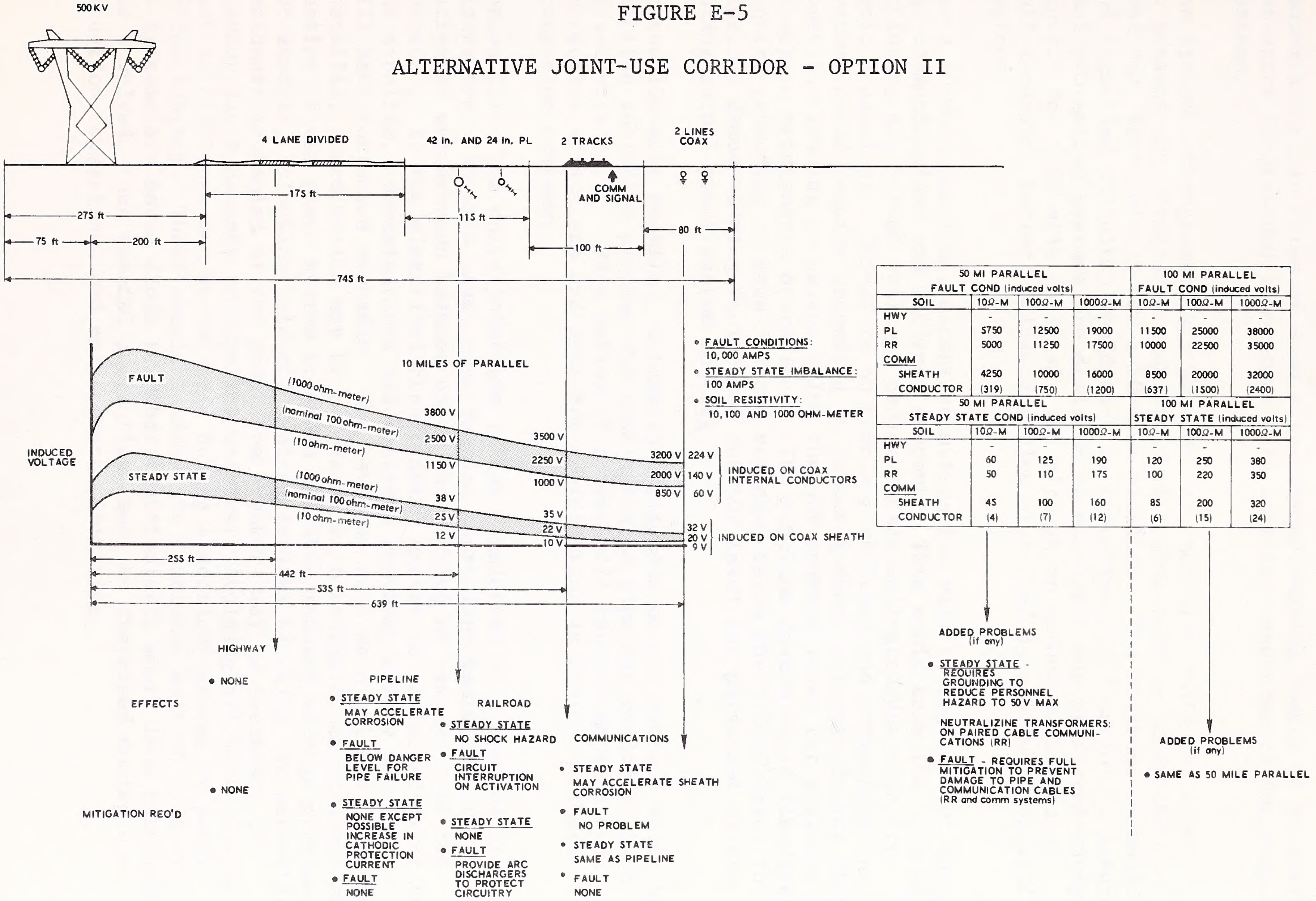
SEPARATION DISTANCES FROM ELECTRICAL TRANSMISSION SYSTEM (ft)

50 MI PARALLEL				100 MI PARALLEL			
SOIL	10Ω-M	100Ω-M	1000Ω-M	SOIL	10Ω-M	100Ω-M	1000Ω-M
FAULT				FAULT			
PL	550	1400	5500	PL	1000	2500	10000
RR	1000	2500	10000	RR	1500	4600	14000
COMM	25	100	350	COMM	200	650	2000
STEADY STATE				STEADY STATE			
PL	550	1400	5500	PL	1000	3500	10000
RR	550	1400	5500	RR	1000	3500	10000
COMM	NO FACTOR W/GROUNDED SHEATH			COMM	NO FACTOR W/GROUNDED SHEATH		

SOURCE: The Aerospace Corporation, 1975

FIGURE E-5

ALTERNATIVE JOINT-USE CORRIDOR - OPTION II


500 KV
4 LANE DIVIDED
42 in. AND 24 in. PL
2 TRACKS
2 LINES COAX
COMM AND SIGNAL
175 ft
275 ft
115 ft
75 ft
200 ft
100 ft
80 ft
745 ft
INDUCED VOLTAGE
FAULT
STEADY STATE
10 MILES OF PARALLEL
(1000 ohm-meter)
(nominal 100 ohm-meter)
(10 ohm-meter)
3800 V
2500 V
1150 V
38 V
25 V
12 V
3500 V
2250 V
1000 V
35 V
22 V
10 V
3200 V
2000 V
850 V
224 V
140 V
60 V
INDUCED ON COAX INTERNAL CONDUCTORS
32 V
20 V
9 V
INDUCED ON COAX SHEATH
255 ft
442 ft
535 ft
639 ft
• FAULT CONDITIONS: 10,000 AMPS
• STEADY STATE IMBALANCE: 100 AMPS
• SOIL RESISTIVITY: 10, 100 AND 1000 OHM-METER
HIGHWAY
PIPELINE
RAILROAD
COMMUNICATIONS
EFFECTS
MITIGATION REQ'D
• NONE
• STEADY STATE MAY ACCELERATE CORROSION
• FAULT BELOW DANGER LEVEL FOR PIPE FAILURE
• STEADY STATE NO SHOCK HAZARD
• FAULT CIRCUIT INTERRUPTION ON ACTIVATION
• STEADY STATE MAY ACCELERATE SHEATH CORROSION
• FAULT NO PROBLEM
• NONE
• STEADY STATE NONE EXCEPT POSSIBLE INCREASE IN CATHODIC PROTECTION CURRENT
• FAULT NONE
• STEADY STATE NONE
• FAULT PROVIDE ARC DISCHARGERS TO PROTECT CIRCUITRY
• STEADY STATE SAME AS PIPELINE
• FAULT NONE
ADDED PROBLEMS (if any)
• STEADY STATE - REQUIRES GROUNDING TO REDUCE PERSONNEL HAZARD TO 50V MAX
NEUTRALIZINE TRANSFORMERS: ON PAIRED CABLE COMMUNICATIONS (RR)
• FAULT - REQUIRES FULL MITIGATION TO PREVENT DAMAGE TO PIPE AND COMMUNICATION CABLES (RR and comm systems)
ADDED PROBLEMS (if any)
• SAME AS 50 MILE PARALLEL

	50 MI PARALLEL FAULT COND (induced volts)			100 MI PARALLEL FAULT COND (induced volts)		
SOIL	10Ω-M	100Ω-M	1000Ω-M	10Ω-M	100Ω-M	1000Ω-M
HWY	-	-	-	-	-	-
PL	5750	12500	19000	11500	25000	38000
RR	5000	11250	17500	10000	22500	35000
COMM						
SHEATH	4250	10000	16000	8500	20000	32000
CONDUCTOR	(319)	(750)	(1200)	(637)	(1500)	(2400)

	50 MI PARALLEL STEADY STATE COND (induced volts)			100 MI PARALLEL STEADY STATE (induced volts)		
SOIL	10Ω-M	100Ω-M	1000Ω-M	10Ω-M	100Ω-M	1000Ω-M
HWY	-	-	-	-	-	-
PL	60	125	190	120	250	380
RR	50	110	175	100	220	350
COMM						
SHEATH	45	100	160	85	200	320
CONDUCTOR	(4)	(7)	(12)	(6)	(15)	(24)

SOURCE: The Aerospace Corporation, 1975

coordination, in terms of some right-of-way sharing, would be necessary, but space is provided consistent with existing requirements for single systems.

The systems arrangements and separations indicated would not appear to present any formidable problems during construction or during operations, particularly for a 10-mile parallel. The railroad communications and signaling circuitry would require inductive coordination to assure that protection systems are designed to dissipate the predicted energy input. For a 10-mile parallel, the mitigation method would include well-grounded, buried, shielded cables protected by gas tubes or similar devices.

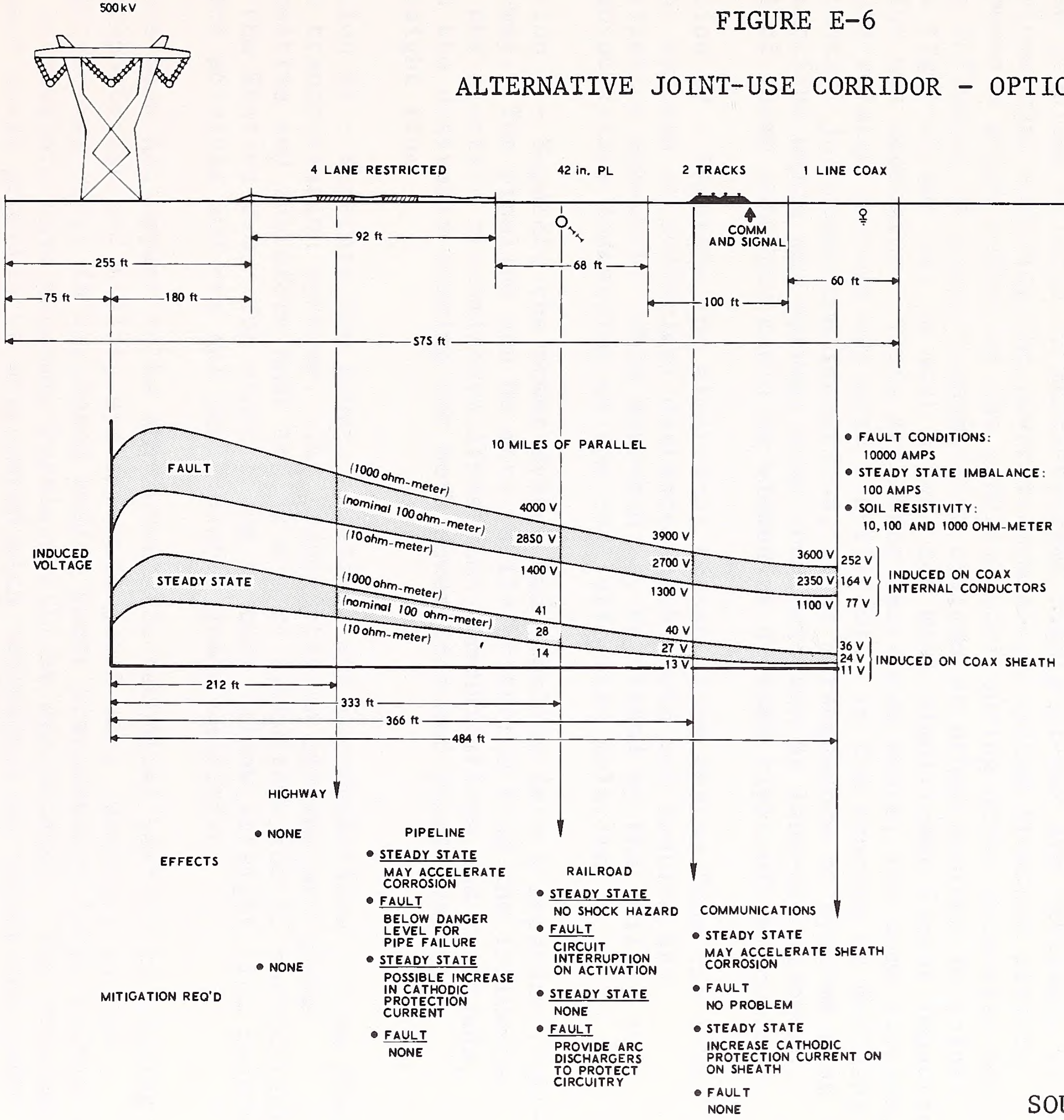
For a 50-mile parallel, extensive mitigation will be required on both the communications and railroad systems. This would take the form of enclosing all buried railroad cables inside well-grounded pipe for fault conditions. Circuitry on both the railroad and communications systems would require grounding to reduce induced voltages during normal powerline loading to values below the 50V maximum level for personnel safety in maintenance operations. The pipeline system would likewise require grounding to keep induced voltages below the 5,000V level for pipeline damage during faults and the 50V level for personnel safety during normal power system loading.

At the 100-mile parallel, extensive mitigation on all systems would be required including placing the coax cable in pipe for medium to high resistivity soils. This action of course will require more cathodic protection of systems and need for coordination in design of these protection systems.

Option III - The third joint-use option considered is presented in Figure E-6. In this case, construction operations would require increased cooperation between users and phasing of systems into the corridor. If the electrical transmission system is installed prior to the pipeline, communications and railroad systems, safety measures will have increased emphasis. When systems such as pipelines are being installed, coordination may be necessary with scheduled maintenance and testing of the power system to avoid possible induced voltage problems. For example, "blocking hold-off" which requires blocking the automatic reclosure mechanism of the powerline breakers may be necessary to prevent shock hazards to pipeline workers. Avoiding all work on systems such as pipelines may be required during electrical storms or power system testing. These considerations are mentioned only to indicate that as systems are moved close together, particularly where long parallels are involved, that special precautions must be exercised during construction, operation, and maintenance activities.

FIGURE E-6

ALTERNATIVE JOINT-USE CORRIDOR - OPTION III



	50 MI PARALLEL FAULT COND (induced volts)			100 MI PARALLEL FAULT COND (induced volts)		
SOIL	10Ω-M	100Ω-M	1000Ω-M	10Ω-M	100Ω-M	1000Ω-M
HWY	-	-	-	-	-	-
PL	7000	14250	20000	14000	28500	40000
RR	6500	13500	19500	13000	27000	39000
COMM						
SHEATH	5500	11750	18000	11000	23500	36000
CONDUCTOR	(412)	(880)	(1350)	(825)	(1763)	(2700)

	50 MI PARALLEL STEADY STATE COND (induced volts)			100 MI PARALLEL STEADY STATE (induced volts)		
SOIL	10Ω-M	100Ω-M	1000Ω-M	10Ω-M	100Ω-M	1000Ω-M
HWY	-	-	-	-	-	-
PL	70	140	205	140	280	410
RR	65	135	200	130	270	400
COMM						
SHEATH	55	120	180	110	240	360
CONDUCTOR	(4)	(9)	(13)	(8)	(18)	(27)

ADDED PROBLEMS
(if any)

- STEADY STATE - REQUIRES GROUNDING TO REDUCE PERSONNEL HAZARD TO 50 V MAX

NEUTRALIZING TRANSFORMERS ON PAIRED CABLE COMMUNICATIONS (RR)

- FAULT - REQUIRES FULL MITIGATION TO PREVENT DAMAGE TO PIPE AND COMMUNICATION CABLES (RR and comm systems)

ADDED PROBLEMS
(if any)

- SAME AS 50 MILE CORRIDOR

SOURCE: The Aerospace Corporation, 1975

The Aerospace Corporation contends, however, that this option as well as Option II can be implemented with prior planning and sound engineering practices. The mitigation measures related to this concept do not vary significantly with that anticipated in Option II. The right-of-way widths and mitigation costs for Option II and III are shown in Table E-2.

The reader is cautioned that the costs in this table and the data presented in Figures E-5 and E-6 are only representative values predicted for a set of specific conditions, and therefore should not be taken as absolute quantities to be expected in similar situations. The effects of electrostatic and electromagnetic induction from high voltage electrical systems is very complex and difficult to predict. System spacing can only be estimated after careful consideration of conditions related to each situation. A very thorough systems approach to these problems on the part of system planners is necessary in each instance.

When problems related to multi-systems rights-of-way are reviewed, it is obvious that removing the power transmission system from the picture removes a great number of the problems confronting other potential users. The influence of power transmission systems on other systems in joint-use right-of-way is, in most cases, the most significant factor impacting joint-use economics. There are other instances where, for some systems, route-related factors are more significant. In the process of defining potential joint-use configurations, other arrangements of systems were identified which may warrant some consideration by land-use planners. All of these concepts could be viewed as divided right-of-way concepts.

Option IV - Separate the electrical transmission system from the other four systems at sufficient distance which would not require any mitigation measures. This approach may be viewed by the utility and transportation industries as the cost effective solution.

Option V - Separate the power system and pipeline into a separate right-of-way. The pipeline can be more easily protected from the influences of the electric transmission lines than communications and railroads, and the desirable routing for both powerlines and pipelines, is a straight line.

Option VI - Separate the power, pipeline, and communications system from the transportation systems. The transportation systems are grade sensitive and therefore must follow a more circuitous route, particularly in the Western U.S. The other three systems follow straight line routing where possible and are not particularly grade sensitive.

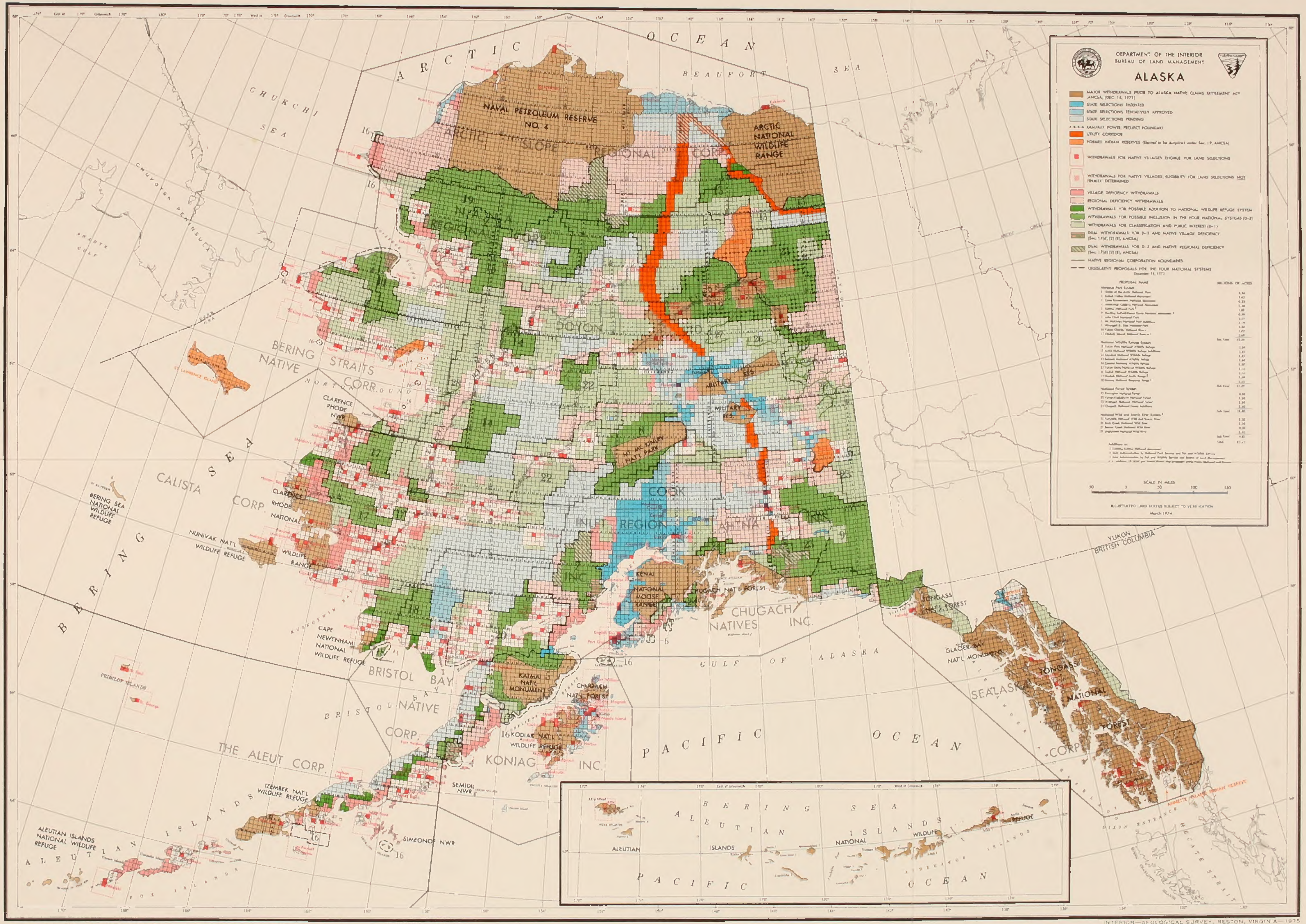
There does not appear to be any formidable technical barrier to placing transportation and utility systems into joint use. However, as the right-of-way width is decreased and/or power transmission level increased, it is possible that economic barriers will be encountered. The greatest impact would probably be associated with techniques to reduce the power transmission system's influence on other user systems. A reasonable approach to joint use would be to group more compatible elements together.

TABLE E-2

JOINT-USE OPTIONS II AND III - WIDTHS AND COSTS

SYSTEM	CONFIGURATION	R/W WIDTH (Ft.)	BASE COST/MILE	MITIGATION COST/MI.			
				10 MI. PLL.	50 MI. PLL.	100 MI. PLL.	
POWER LINE	500KV Single Circuit	275	$ 220,000	$10,000	$ 10,000	$ 10,000	OPTION - II
HIGHWAY	4 Lane "Intermediate"	175	1,500,000	0	0	0	
PIPELINE	2 Lines 24" and 42"	115	500,000	0	3,000	3,000	
RAILROAD	Two Tracks	100	600,000	10,000	30,000	30,000	
COMMUNICATION	Two Buried Coax	80	300,000	5,000	60,000	150,000	
TOTAL CORRIDOR		745	$3,120,000	$25,000	$103,000	$193,000	
POWER LINE	500KV Single Circuit	225	$ 220,000	$10,000	$ 10,000	$ 10,000	OPTION - III
HIGHWAY	4 Lane "Restricted"	92	1,500,000	0	0	0	
PIPELINE	One 42" Line	68	300,000	0	1,500	1,500	
RAILROAD	Two Tracks	100	600,000	10,000	30,000	30,000	
COMMUNICATION	One Buried Coax	60	80,000	2,000	30,000	75,000	
TOTAL CORRIDOR		575	$2,900,000	$22,000	$ 71,500	$116,500	

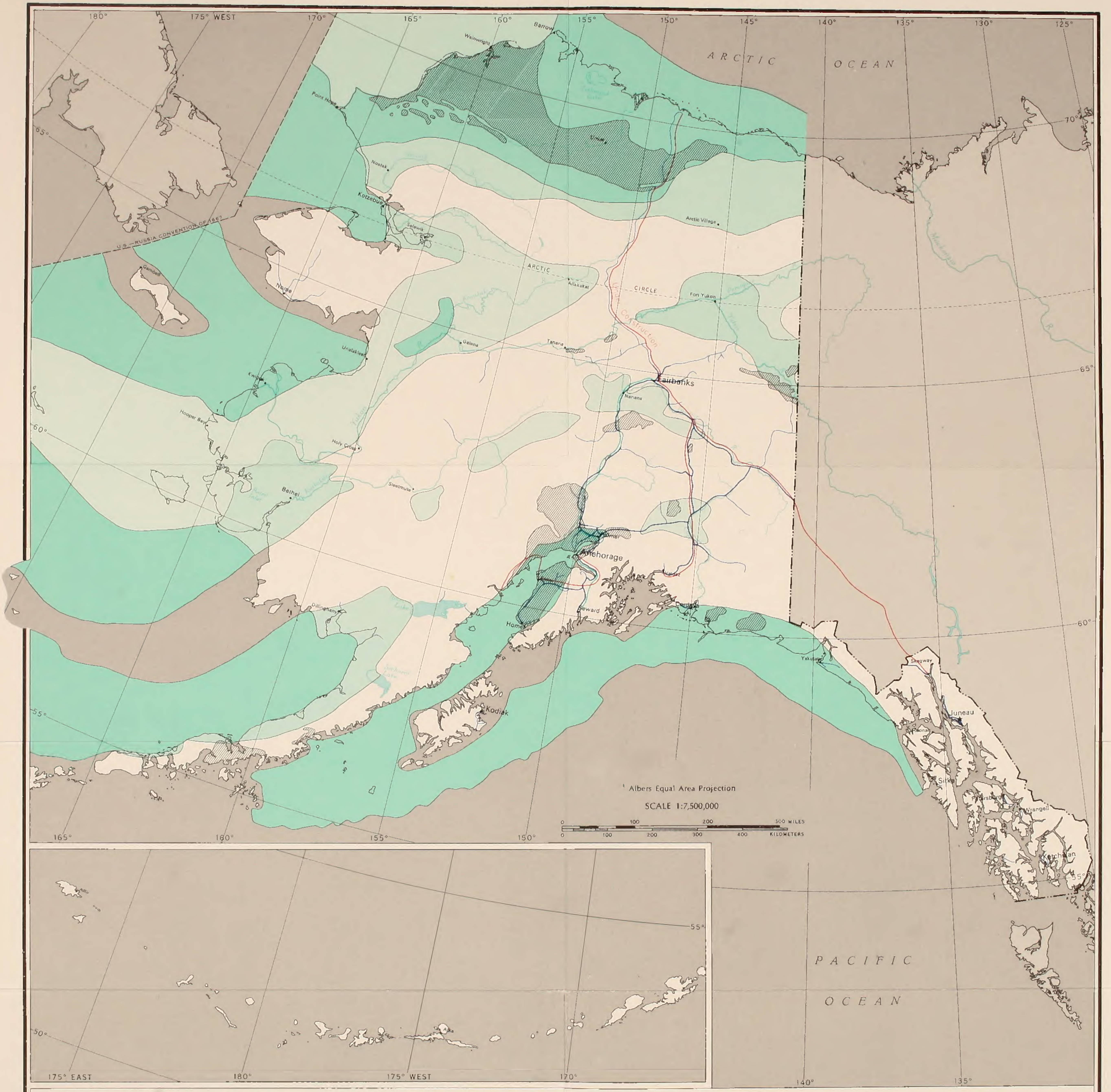
SOURCES: The Aerospace Corporation, 1975 and Industry


DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
ALASKA
MAJOR WITHDRAWALS PRIOR TO ALASKA NATIVE CLAIMS SETTLEMENT ACT (ANCSA) (DEC. 18, 1971)
STATE SELECTIONS PATENTED
STATE SELECTIONS TENTATIVELY APPROVED
STATE SELECTIONS PENDING
RAMPART POWER PROJECT BOUNDARY
UTILITY CORRIDOR
FORMER INDIAN RESERVES (Elected to be Acquired under Sec. 19, ANCSA)
WITHDRAWALS FOR NATIVE VILLAGES ELIGIBLE FOR LAND SELECTIONS
WITHDRAWALS FOR NATIVE VILLAGES, ELIGIBILITY FOR LAND SELECTIONS NOT FINALLY DETERMINED
VILLAGE DEFICIENCY WITHDRAWALS
REGIONAL DEFICIENCY WITHDRAWALS
WITHDRAWALS FOR POSSIBLE ADDITION TO NATIONAL WILDLIFE REFUGE SYSTEM
WITHDRAWALS FOR POSSIBLE INCLUSION IN THE FOUR NATIONAL SYSTEMS (D-2)
WITHDRAWALS FOR CLASSIFICATION AND PUBLIC INTEREST (D-1)
DUAL WITHDRAWALS FOR D-2 AND NATIVE VILLAGE DEFICIENCY (Sec. 17(d) (2) (E), ANCSA)
DUAL WITHDRAWALS FOR D-2 AND NATIVE REGIONAL DEFICIENCY (Sec. 17(d) (2) (E), ANCSA)
NATIVE REGIONAL CORPORATION BOUNDARIES
LEGISLATIVE PROPOSALS FOR THE FOUR NATIONAL SYSTEMS
PROPOSAL NAME
MILLIONS OF ACRES
SCALE IN MILES
50 0 50 100 150
ILLUSTRATED LAND STATUS SUBJECT TO VERIFICATION
March 1974
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
NAVAL PETROLEUM RESERVE NO. 4
ARCTIC SLOPE REGIONAL CORP.
ARCTIC NATIONAL WILDLIFE RANGE
NANA REGIONAL
DOYON
BERING STRAITS NATIVE CORP.
CLARENCE RHODE NWR
NORTON SOUND
CHUKOTSK PENINSULA
ANADYR GULF
ST. LAWRENCE ISLAND
MILITARY RES.
MT. MC KINLEY NAT'L PARK
COOK INLET REGION INC.
AHTNA
CALISTA CORP.
CLARENCE RHODE NATIONAL WILDLIFE RANGE
BERING SEA NATIONAL WILDLIFE REFUGE
NUNIVAK NAT'L WILDLIFE REFUGE
BERING SEA
KENAI NATIONAL MOOSE RANGE
CHUGACH NAT'L FOREST
CHUGACH NATIVES INC.
TONGASS NAT'L FOREST
GLACIER BAY NAT'L MONUMENT
YUKON
BRITISH COLUMBIA
GULF OF ALASKA
CAPE NEWENHAM NATIONAL WILDLIFE REFUGE
BRISTOL BAY
BRISTOL BAY NATIVE CORP.
KATMAI NAT'L MONUMENT
KODIAK NAT'L WILDLIFE REFUGE
KONIAG INC.
PRIBILOF ISLANDS
THE ALEUT CORP.
IZEMBEK NAT'L WILDLIFE REFUGE
SEMIDI NWR
SIMEONOF NWR
ALEUTIAN ISLANDS NATIONAL WILDLIFE REFUGE
ALEUTIAN ISLANDS
FOX ISLANDS
PACIFIC OCEAN
SEALASKA CORP.
TONGASS NATIONAL FOREST
ANNETTE ISLAND INDIAN RESERVE
DIXON ENTRANCE
HECATE STRAIT
BERING SEA
ALEUTIAN ISLANDS NATIONAL WILDLIFE REFUGE
PACIFIC OCEAN

TITLE I P.L. 93—153 TRANSPORTATION AND UTILITY CORRIDOR STUDY JULY 1, 1975

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1975

MAP NO. 2



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AND UTILITY CORRIDOR STUDY
JULY 1, 1975

ALASKA

EXISTING RIGHTS-OF-WAY SYSTEMS

- Federal-aid primary highways
- Gravel roads of major significance
- Railroads
- Pipelines

ORGANIC FUEL DEPOSITS

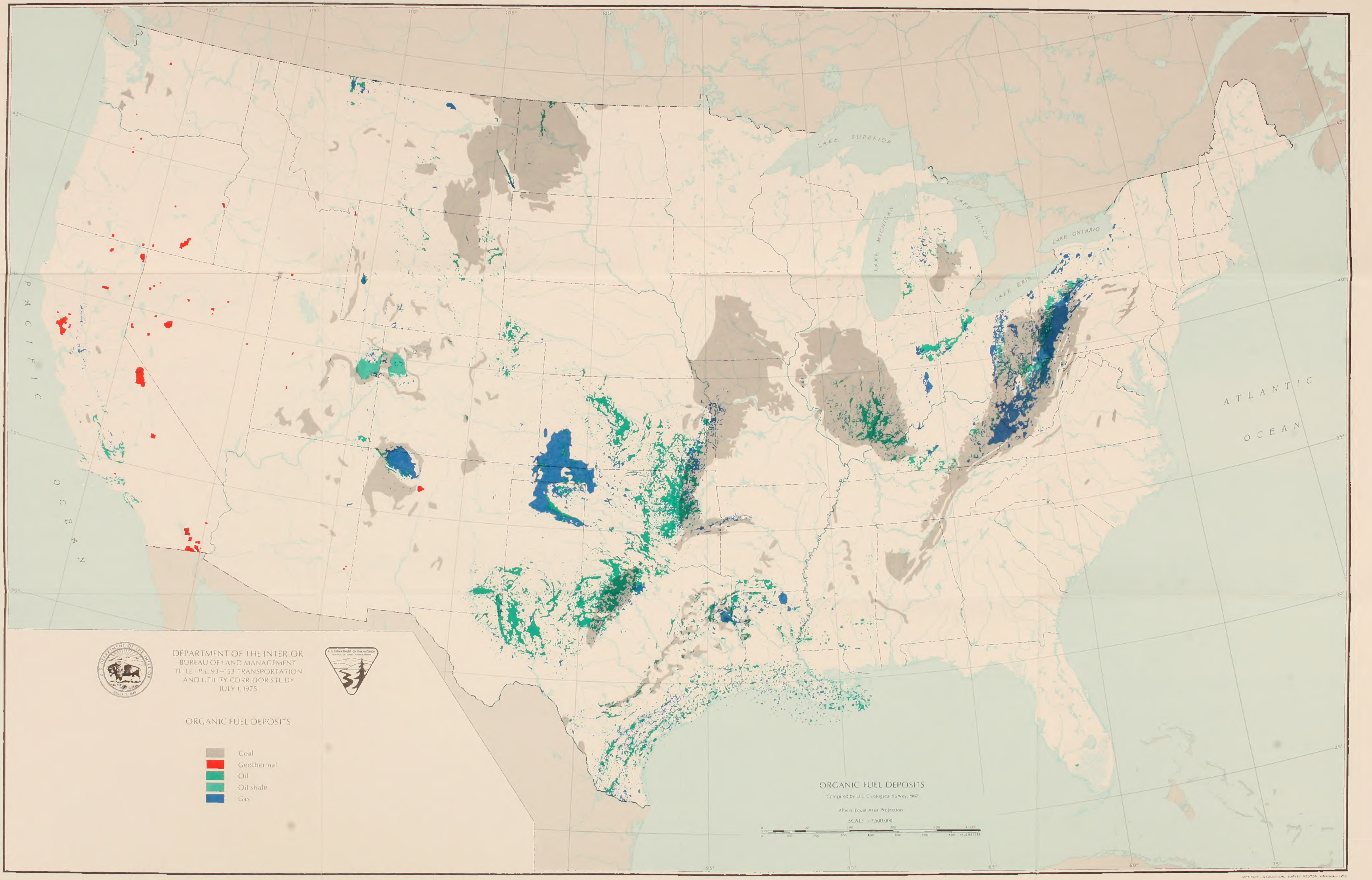
Petroleum reserves

🟩 Rank I—highest reserves
🟩 Rank II
🟩 Rank III—lowest reserves

▨ Coal deposits

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1975

MAP NO. 3



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AND UTILITY CORRIDOR STUDY
JULY 1, 1975

ORGANIC FUEL DEPOSITS

▨	Coal
🟥	Geothermal
🟩	Oil
🟩	Oil shale
🟦	Gas

ORGANIC FUEL DEPOSITS

Compiled by U.S. Geological Survey, 1967

Albers Equal Area Projection

SCALE 1:7,500,000

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—[illegible]

MAP NO. 4